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Supporting Information

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Iron-Catalyzed 1,2-Addition of Perfluoroalkyl Iodides to Alkynes and Alkenes**

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anie_201402511_sm_miscellaneous_information.pdf

1. General Considerations.

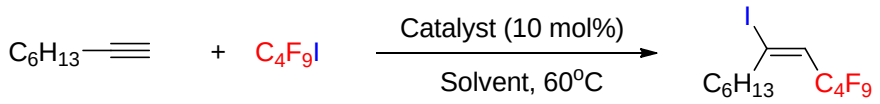
All commercially available compounds were used as received. ^{1}H and ^{13}C spectra were recorded on a Bruker Avance 400 spectrometer, and $CDCl_3$ was purchased from Aldrich. The chemical shifts (δ) are given in parts per million relative to internal standard TMS (0 ppm for ^{1}H), $CDCl_3$ (77.0 ppm for ^{13}C). Solvents were purified using a two-column solid-state purification system (Innovative Technology, NJ, USA) and transferred to the glove box without exposure to air. Unless otherwise noted, all other reagents and starting materials were purchased from commercial sources and used without further purification.

2. Screening Results.

In a 4 mL sealed glass vial, 1-Octyne (**1a**), C_4F_9I (1.2-1.5 equiv.) and base were dissolved in dry solvent under N_2 following the condition listed in the table below. The mixture was stirred at 60°C in the dark for 18-24h. The reaction was quenched by aq.HCl solution and diluted with diethyl ether. Decane (60 ul) was added to the organic layer as an internal standard and the solution was analyzed by GC to give the yield.

2.1 Screening different metal catalysts.

Table S1



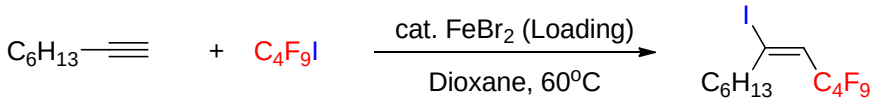
1a **2a** **3a**

Entry	Catalyst	co-Cat.	Base	Solvent	o-TMEDA	Conversion	Yield
1	---	---	Cs_2CO_3	Dioxane	---	74%	51%
2	CuI	---	Cs_2CO_3	Dioxane	---	89%	49%
3	$CoBr_2$	---	Cs_2CO_3	Dioxane	2 equiv.	67%	30%
4	$Cu(OTf)_2$	---	Cs_2CO_3	Dioxane	2 equiv.	77%	23%
5	$NiCl_2$.dme	CuI	Cs_2CO_3	Dioxane	---	98%	61%
6	$NiCl_2$.dme	CuI	Cs_2CO_3	THF	---	77%	27%
7	$NiCl_2$.dme	CuI	^{t}BuOK	Dioxane	---	97%	0
8	$NiCl_2$.dme	---	Cs_2CO_3	Dioxane	2 equiv.	68%	30%
9	$FeBr_2$	CuI	Cs_2CO_3	Dioxane	---	94%	63%
10	$FeBr_2$	---	Cs_2CO_3	Dioxane	---	96%	68%
11	$FeBr_2$	---	Cs_2CO_3	Dioxane	2 equiv.	65%	31%

Condition: **1a** (0.5 mmol), **2a** (1.2 equiv.), Catalyst (10 mol%), co-Catalyst (10 mol%), Base (1.5 equiv.), o-TMEDA (2 equiv.), Solvent (2 mL), 60°C, 18-24h. o-TMEDA = bis[2-(N,N-dimethylaminoethyl)]ether

2.2 Screening concentration.

Table S2



1a **2a** **3a**

Entry	Loading	Alkyne (Con.)	Base (equiv.)	Conversion	Yield
1	5%	0.25M	Cs_2CO_3 (0.8)	99%	95%(87%)
2	5%	0.25M	---	0	0
3	---	0.25M	---	0	0
4	---	0.25M	Cs_2CO_3 (2.0)	97%	63%
5	---	0.25M	Cs_2CO_3 (0.2)	58%	47%
6	---	0.25M	CsCl (0.2)	0	0
7	---	0.25M	K_2CO_3 (0.2)	0	0
8	---	0.25M	DABCO (0.2)	0	0
9	---	0.25M	Cs_2CO_3 (0.2)	43%	17%
10	---	0.50M	Cs_2CO_3 (0.2)	81%	79%
11	---	1.00M	Cs_2CO_3 (0.2)	91%	90%
12	---	1.00M	Cs_2CO_3 (0.25)	96%	95%(87%)

Condition: **1a** (1.0 mmol), **2a** (1.5 equiv.), Catalyst (5 mol%), Base (1.5 equiv.), Dioxane, 60°C, 18-24h.

3. General Procedure for Experiments.

3.1 General procedure for addition to alkyne.

Cs_2CO_3-catalyed reaction:

In a 4 mL sealed glass vial, Cs_2CO_3 (81.5 mg, 0.25 mmol, 0.25equiv.), alkyne (1.0 mmol) or alkene (1.0 mmol), Perfluoroalkyl idodide (1.5 mmol, 1.5equiv.) were dissolved in dry dioxane (1 mL) under N_2. The mixture was stirred at 60°C in the dark for 18-24h, and the reaction was quenched by aq.HCl solution and extracted with diethyl ether. The organic layer was combined and concentrated under vacuum and the residue was purified by column chromatography on silica gel with a gradient eluant of Hexane and ethyl acetate affording the product.

$FeBr_2$-catalyed reaction:

In a 4 mL sealed glass vial, $FeBr_2$ (10.8 mg, 0.05mmol, 0.1equiv.), Cs_2CO_3 (130.4 mg, 0.4 mmol, 0.8equiv.), alkyne or alkene (0.5 mmol), Perfluoroalkyl idodide (0.75 mmol, 1.5equiv.) were dissolved in dry dioxane (2 mL) under N_2. The mixture was stirred at 60°C in the dark for 18-24h, and the reaction was quenched by aq.HCl solution and extracted with diethyl ether. The organic layer was combined and concentrated under vacuum and the residue was purified by column chromatography

on silica gel with a gradient eluant of Hexane and ethyl acetate affording the product.

For CF_3I, firstly, CF_3I (1.5mmol, 3equiv.) was dissolved in the dioxane (2 mL) at room temperature, then this solvent was added to the mixture of $FeBr_2$ (10.8 mg, 0.05mmol, 0.1equiv.), Cs_2CO_3 (130.4 mg, 0.4 mmol, 0.8equiv.), alkyne or alkene (0.5 mmol) in a 4 mL sealed glass vial under N_2.The mixture was stirred at 60^{o}C in the dark for 18-24h, and the reaction was quenched by aq.HCl solution and extracted with diethyl ether. The organic layer was combined and concentrated under vacuum and the residue was purified by column chromatography on silica gel with a gradient eluant of hexane and ethyl acetate affording the product.

3.2 Procedures for coupling reactions.

In a 4 mL sealed glass vial, $Fe(acac)_3$ (13.1 mg, 0.0373 mmol, 0.5equiv.) and compound **4a** (27.0 mg, 0.0746 mmol) were dissolved in dry THF (1 mL) and NMP (200 uL) under N_2. Then $^nC_5H_9MgBr$ (75 uL, 2.0M, 0.15 mmol, 2.0 equiv.) was added The mixture was stirred at -30^{o}C for 1h, and the reaction was quenched by aq.NH_4Cl solution and extracted with diethyl ether. The organic layer was combined and concentrated under vacuum and the residue was purified by column chromatography on silica gel with a gradient eluant of hexane affording the product **6a** (15.8 mg, 69%).

In a 4 mL sealed glass vial, $PdCl_2(PPh_3)_2$ (7.0 mg, 0.01 mmol, 0.1equiv.), K_2CO_3 (3.1 mg, 0.022 mmol, 0.22equiv.), $PhB(OH)_2$ (36.6 mg, 0.3 mmol, 3equiv.) and compound **3n** (57.0 mg, 0.1 mmol) were dissolved in Toluene (1 mL) and H_2O (200 uL) under N_2. The mixture was stirred at 80^{o}C for 16h. After that, another K_2CO_3 (3.0 mg, 0.022 mmol, 0.22equiv.) and $PhB(OH)_2$ (36.6 mg, 0.3 mmol, 3equiv.) were added and the reaction was stirred at 80^{o}C for additional 16h followed by quenched with water and extracted with diethyl ether. The organic layer was combined and concentrated under vacuum and the residue was purified by column chromatography on silica gel with a gradient eluant of hexane and ethyl acetate affording the product **6b** (45.3 mg, 86%).

In a 4 mL sealed glass vial, **4l** (58.0 mg, 0.126 mmol), $Pd(PPh_3)_4$ (9.3 mg, 0.008 mmol, 0.063equiv.), K_2CO_3 (43.5 mg, 0.315 mmol, 2.5equiv.), *E*-C_6H_{13}-CH=CH-$B(OH)_2$ (49.1 mg, 0.315 mmol, 2.5equiv.) were dissolved in THF (1 mL) under N_2. The mixture was stirred at 65^{o}C for 18h. The reaction was filtered by fast column and washed with diethyl ether. The organic layer was combined and concentrated under vacuum and the residue was purified by column chromatography on silica gel with a gradient eluant of Hexane and ethyl acetate affording the product **6c** (42.2 mg, 75%).

In a 4 mL sealed glass vial, **4h** (56.0 mg, 0.142 mmol), $Pd(PPh_3)_4$ (16.4 mg, 0.014 mmol, 0.1equiv.), CuI (5.4 mg, 0.028 mmol, 0.2equiv.), 1-Octyne (35.8 mg, 0.325 mmol, 2.3equiv.) were dissolved in TEA (1 mL) under N_2. The mixture was stirred at

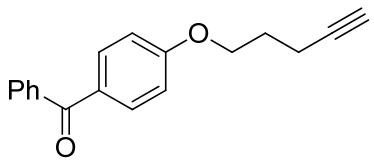
50°C for 16h. The reaction was filtered by fast column and washed with diethyl ether. The organic layer was combined and concentrated under vacuum and the residue was purified by column chromatography on silica gel with a gradient eluant of hexane and ethyl acetate affording the product **6d** (49.2 mg, 92%).

In a 4 mL sealed glass vial, CuI (4.7 mg, 0.024 mmol, 0.2equiv.), 1,10-Phenanthroline (4.4 mg, 0.024 mmol, 0.2equiv.), PPh_3 (13.1 mg, 0.050 mmol, 0.4equiv.), K_3PO_4 (44.0 mg, 0.207 mmol, 1.7equiv.) and compound **3j** (59.0 mg, 0.124 mmol) were dissolved in Toluene (1 mL) under N_2, then PhSH (26.0 mg, 0.236 mmol, 1.9 equiv.) was added. The mixture was stirred at 110°C for 16h. The reaction was quenched with aq. HCl and extracted with diethyl ether. The organic layer was combined and concentrated under vacuum and the residue was purified by column chromatography on silica gel with a gradient eluant of hexane and ethyl acetate affording the product **6e** (45.9 mg, 81%).

In a 4 mL sealed glass vial, $FeBr_2$ (7.1 mg, 0.01 mmol, 0.1equiv.) and compound **5e** (60.0 mg, 0.174 mmol) were dissolved in NMP (0.73 mL) under N_2, then the relevant alkyne Gridge reagent (0.55 mL, 0.5M, 0.275 mmol, 1.6 equiv.) was added. The mixture was stirred at room temperature for 16h. The reaction was quenched with aq. HCl and extracted with diethyl ether. The organic layer was combined and concentrated under vacuum and the residue was purified by column chromatography on silica gel with a gradient eluant of hexane and ethyl acetate affording the product **6f** (36.1 mg, 50%).

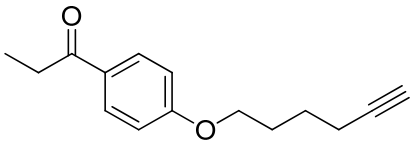
3.3 General procedure for the synthesis of the substrates

These substrateswere synthesized according to the literature by Mitsunobu reaction[S1].



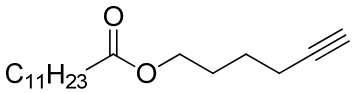
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 8.4 Hz, 2H), 7.75 (d, *J* = 7.6 Hz, 2H), 7.56 (t, *J* = 7.6 Hz, 1H), 7.47 (t, *J* = 7.6 Hz, 2H), 6.96 (d, *J* = 8.4 Hz, 2H), 4.16 (t, *J* = 6.4 Hz, 2H), 2.43 (td, *J* = 6.8, 2.8 Hz, 2H), 2.04 (tt, *J* = 6.8, 6.4 Hz, 2H), 1.99 (t, *J* = 2.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 195.5, 162.5, 138.3, 132.5, 131.8, 130.2, 129.7, 128.2, 114.0, 83.1, 69.1, 66.3, 28.0, 15.1; HRMS: m/z (ESI) calculated $[M+H]^+$: 265.1229, measured: 265.1238.

[S1] a) X. Chen, J. Thomas, P. Gangopadhyay, R. A. Norwood, N. Peyghambarian, D. V. McGrath, *J. Am. Chem. Soc.***2009**, *131*, 13840-13843. b) R. R. Frey, C. K. Wada, et. al, *Bio. & Med. Chem. Lett.* **2002**, *12*, 3443-3447.

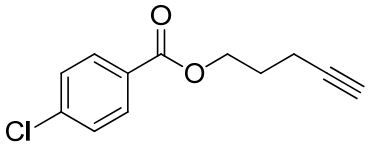


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, *J* = 8.8 Hz, 2H), 6.92 (d, *J* = 8.8 Hz, 2H), 4.05 (t, *J* = 6.4 Hz, 2H), 2.96 (q, *J* = 7.2 Hz, 2H), 2.37-2.25 (m, 2H), 2.07-1.88 (m, 3H), 1.81-1.68 (m, 2H), 1.21 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.5, 162.7, 130.2, 129.8, 114.0, 83.9, 68.7, 67.4, 31.3, 28.0, 24.9, 18.1, 8.4; HRMS: m/z (ESI) calculated $[M+Ag]^+$: 337.0358, measured: 337.0357.

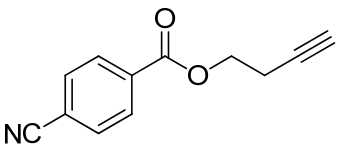
These substrateswere synthesized from the acyl chloride and alcohol with pyridine or TEA as base in DCM at room temperature according to the literature[S2].



^{1}H NMR (400 MHz, $CDCl_3$) δ 4.09 (t, *J* = 6.4 Hz, 2H), 2.37-2.18 (m,4H), 2.01-1.93 (m,1H), 1.82-1.71 (m,2H), 1.67-1.55(m,4H),1.39-1.15 (m,16H), 0.88 (t, *J* = 6.8 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.0, 83.8, 68.6, 63.6, 34.3, 31.9, 29.5, 29.4, 29.3, 29.2, 29.1, 29.0, 27.6, 24.9, 24.8, 22.6, 18.0, 14.1; HRMS: m/z (ESI) calculated $[M+Ag]^+$: 387.1453, measured: 387.1434.



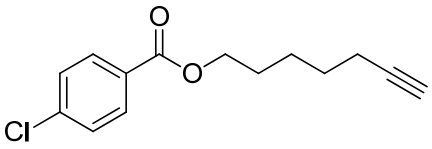
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 (d, J = 8.0 Hz, 2H), 7.39 (d, J = 8.0 Hz, 2H), 4.23 (t, J = 6.0 Hz, 2H), 2.41-2.32 (m, 2H), 2.04-1.93 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.4, 139.2, 130.8, 128.5, 128.6, 82.8, 69.1, 63.6, 27.5, 15.2; HRMS: m/z (ESI) calculated $[M+Ag]^+$: 328.9499, measured: 328.9495.



^{1}H NMR (400 MHz, $CDCl_3$) δ 8.16 (d, J = 8.8 Hz, 2H), 7.76 (d, J = 8.8 Hz, 2H), 4.47

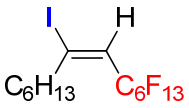
[S2] S. Peddibhotla, Y. Dang, J. O. Liu, D. Romo, *J. Am. Chem. Soc.***2007**, *129*, 12222-12231.

(t, J = 6.4 Hz, 2H), 2.69 (td, J = 6.4, 2.8 Hz, 2H), 2.05 (t, J = 2.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.6, 133.7, 132.2, 130.1, 117.9, 116.5, 79.6, 70.2, 63.2, 19.0; HRMS: m/z (ESI) calculated $[M+Ag]^+$: 305.9684, measured: 305.9682.

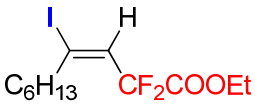


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, J = 8.4 Hz, 2H), 7.40 (d, J = 8.4 Hz, 2H), 4.32 (t, J = 6.4 Hz, 2H), 2.23 (td, J = 6.8, 2.4 Hz, 2H), 1.97 (t, J = 2.4 Hz, 1H), 1.78 (tt, J = 7.2, 6.8 Hz, 2H), 1.65-1.50 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.6, 139.1, 130.8, 128.7, 128.5, 84.0, 68.4, 64.9, 28.0, 27.9, 25.0, 18.2; HRMS: m/z (ESI) calculated $[M+Ag]^+$: 356.9811, measured: 356.9796.

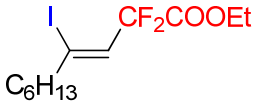
3.4 The characterization of the new products



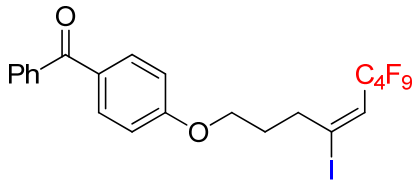
^{1}H NMR (400 MHz, $CDCl_3$) δ 6.32 (d, J = 14.4 Hz, 1H), 2.69-2.56 (m, 2H), 1.65-1.49 (m, 2H), 1.41-1.21 (m, 6H), 0.95-0.83 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 126.6 (t, J = 243.0 Hz), 126.1 (t, J = 5.7 Hz), 120-100 (m), 41.2, 31.5, 30.1, 28.2, 22.5, 13.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.2 (t, J = 9.8 Hz, 3F), -105.6 (t, J = 12.0 Hz, 2F), -121.9 (m, 2F), -123.1 (m, 2F), -123.5 (m, 2F), -126.4 (m, 2F); HRMS: m/z (APCI) calculated $[M]^+$: 555.9933, measured: 555.9920.



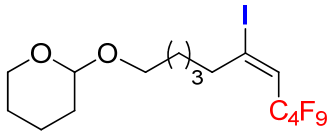
^{1}H NMR (400 MHz, $CDCl_3$) δ 6.40 (t, J = 12.8 Hz, 1H), 4.40-4.27 (m, 2H), 2.63-2.54 (m, 2H), 1.62-1.47 (m, 2H), 1.46-1.21 (m, 9H), 0.95-0.84 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.2 (t, J = 34.2 Hz), 131.2 (t, J = 26.8 Hz), 119.6 (t, J = 7.4 Hz), 111.5 (t, J = 251.0 Hz), 63.3, 40.7, 31.5, 29.8, 28.0, 22.5, 14.0, 13.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ -97.7(s); HRMS: m/z (ESI) calculated $[M+Na]^+$: 383.0296, measured: 383.0286.



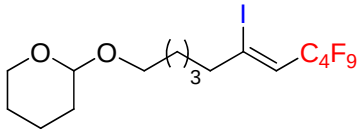
^{1}H NMR (400 MHz, $CDCl_3$) δ 6.37 (t, *J* = 11.6 Hz, 1H), 4.41-4.31(m, 2H), 2.59 (t, *J* = 7.2 Hz, 2H), 1.61-1.50 (m, 2H), 1.37 (t, *J* = 7.2 Hz, 3H), 1.33-1.24 (m, 6H), 0.89 (t, *J* = 6.8 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.6 (t, *J* = 34.2 Hz), 128.1 (t, *J* = 29.5 Hz), 115.0 (t, *J* = 10.0 Hz), 112.1 (t, *J* = 240.9 Hz), 63.2, 46.7, 31.4, 28.9, 27.6, 22.5, 14.0, 13.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ -97.9(s); HRMS: m/z (ESI) calculated $[M+Na]^+$: 383.0296, measured: 383.0291.



^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 8.4 Hz, 2H), 7.75 (d, *J* = 8.0 Hz, 2H), 7.57 (t, *J* = 6.8 Hz, 1H), 7.48 (t, *J* = 6.8 Hz, 2H), 6.95 (d, *J* = 8.4 Hz, 2H), 6.40 (t, *J* = 14.6 Hz, 1H), 4.08 (t, *J* = 6.4 Hz, 2H), 2.94-2.83 (m, 2H), 2.18-2.05 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 195.4, 162.2, 138.2, 132.5, 131.8, 130.2, 129.7, 128.1, 127.3(t, *J* = 23.8 Hz), 120.9(t, *J* = 6.0 Hz), 113.9, 120-100(m), 66.1, 37.8, 29.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.0(t, *J* = 9.4 Hz, 3F), -105.8 (t, *J* = 12.0 Hz, 2F), -124.1 (m, 2F), -125.8 (m, 2F); HRMS: m/z (ESI) calculated $[M+H]^+$: 611.0129, measured: 611.0131. *Z* product: ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.0(m, 3F), -108.9 (t, *J* = 12.4 Hz, 2F), -123.8 (m, 2F), -125.7 (m, 2F); HRMS: m/z (ESI) calculated $[M+H]^+$: 611.0129, measured: 611.0126.

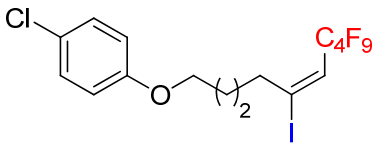


^{1}H NMR (400 MHz, $CDCl_3$) δ 6.34 (t, *J* = 14.4 Hz, 1H), 4.63-4.57 (m, 1H), 3.93-3.84 (m, 1H), 3.77 (tt, *J* = 10.0, 6.4 Hz, 1H), 3.56-3.49 (m, 1H), 3.44 (tt, *J* = 10.0, 6.4 Hz, 1H), 2.67 (t, *J* = 7.2 Hz, 2H), 1.90-1.80 (m, 1H), 1.78-1.70 (m, 1H), 1.69-1.51 (m, 8H), 1.49-1.38 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 126.4 (t, *J* = 23.8 Hz), 122.8 (t, *J* = 6.4 Hz), 120-100 (m), 98.8, 67.2, 62.2, 41.1, 30.7, 29.8, 29.4, 25.4, 25.2, 19.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.0 (t, *J* = 9.4 Hz, 3F), -105.6 (t, *J* = 12.0 Hz, 2F), -124.2 (m, 2F), -125.8 (m, 2F); HRMS: m/z (ESI) calculated $[M+Na]^+$: 565.0262, measured: 565.0263.



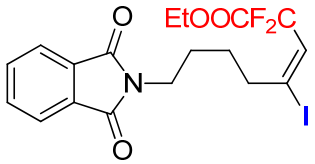
^{1}H NMR (400 MHz, $CDCl_3$) δ 6.24 (t, *J* = 12.8 Hz, 1H), 4.63-4.50 (m, 1H), 3.91-3.81

(m, 1H), 3.80-3.70 (m, 1H), 3.55-3.46 (m, 1H), 3.43-3.35 (m, 1H), 2.76-2.63 (m, 2H), 1.80-1.33 (m, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 121.6 (t, *J* = 23.5 Hz), 116.5 (t, *J* = 6.1 Hz), 120-100 (m), 98.9, 67.2, 62.4, 48.3, 30.7, 29.3, 28.9, 25.4, 24.8, 19.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.0 (t, *J* = 10.1 Hz, 3F), -108.7 (t, *J* = 12.4 Hz, 2F), -123.9 (m, 2F), -125.8 (m, 2F); HRMS: m/z (ESI) calculated $[M+Na]^+$: 565.0262, measured: 565.0247.

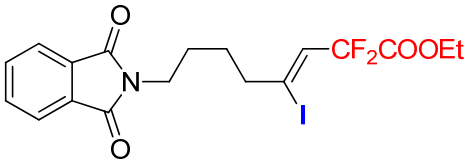


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28-7.19 (m, 2H), 6.87-6.77 (m, 2H), 6.36 (t, *J* = 14.0 Hz, 1H), 4.00-3.89 (m, 2H), 2.78-2.64 (m, 2H), 1.87-1.70 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.5, 129.3, 126.9 (t, *J* = 23.5 Hz), 125.5, 122.2 (t, *J* = 6.4 Hz), 115.7, 120-100 (m), 67.6, 40.6, 27.8, 26.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.0 (t, *J* = 9.4 Hz, 3F), -105.5 (t, *J* = 12.4 Hz, 2F), -124.2 (m, 2F), -125.8 (m, 2F); HRMS: m/z (APCI) calculated $[M]^+$: 553.9556, measured: 553.9550.

Z product: ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.0 (t, *J* = 9.4 Hz, 3F), -108.8 (t, *J* = 12.4 Hz, 2F), -123.8 (m, 2F), -125.8 (m, 2F); LRMS: m/z (EI) 427 (M-I), 299, 128 (100), 127, 111.

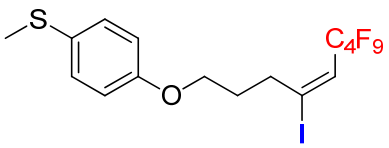


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89-7.78 (m, 2H), 7.74-7.65 (m, 2H), 6.38 (t, *J* = 12.8 Hz, 1H), 4.28 (q, *J* = 7.2 Hz, 2H), 3.67 (t, *J* = 6.4 Hz, 2H), 2.69-2.56 (m, 2H), 1.72-1.51 (m, 4H), 1.31 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.3, 163.1 (t, *J* = 34.2 Hz), 133.9, 132.1, 131.8 (t, *J* = 26.8 Hz), 123.2, 118.4 (t, *J* = 7.4 Hz), 111.5 (t, *J* = 251.0 Hz), 63.4, 39.9, 37.6, 27.2, 27.1, 13.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ -97.7(s); HRMS: m/z (ESI) calculated $[M+H]^+$: 478.0327, measured: 478.0329.

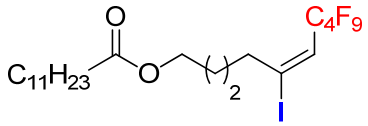


^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02-7.80 (m, 2H), 7.78-7.58 (m, 2H), 6.41 (t, *J* = 11.2 Hz, 1H), 4.35 (q, *J* = 7.2 Hz, 2H), 3.82-3.63 (m, 2H), 2.76-2.55 (m, 2H), 1.76-1.56(m, 4H), 1.36 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.3, 162.6, 134.0, 132.0, 128.8 (t, *J* = 29.5 Hz), 123.2, 113.8 (t, *J* = 9.7 Hz), 111.9 (t, *J* = 247.0 Hz), 63.3, 45.9, 37.3, 26.9, 26.1, 13.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ -98.0(s); HRMS: m/z (ESI)

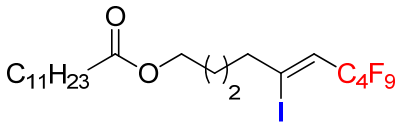
calculated $[M+Na]^+$: 500.0146, measured: 500.0086.



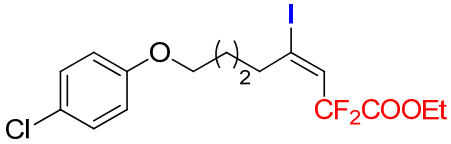
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26 (d, *J* = 8.8 Hz, 2H), 6.83 (d, *J* = 8.8 Hz, 2H), 6.38 (t, *J* = 14.0 Hz, 1H), 3.97 (t, *J* = 6.0 Hz, 2H), 2.86 (t, *J* = 7.2 Hz, 2H), 2.45 (s, 3H), 2.12-1.99 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.2, 130.0, 129.0, 127.2 (t, *J* = 24.0 Hz), 121.2, 115.1, 120-100 (m), 66.1, 38.0, 29.7, 18.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.0 (t, *J* = 9.8 Hz, 3F), -105.8 (t, *J* = 13.2 Hz, 2F), -124.1 (m, 2F), -125.8 (m, 2F); LRMS: m/z (EI) 425 (M-I), 413, 285, 140 (100), 125, 117, 97, 77.
Z product: ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.0 (t, *J* = 9.4 Hz, 3F), -108.9 (t, *J* = 12.4 Hz, 2F), -123.8 (m, 2F), -125.8 (m, 2F); HRMS: m/z (ESI) calculated $[M+K]^+$: 590.9303, measured: 590.9391.



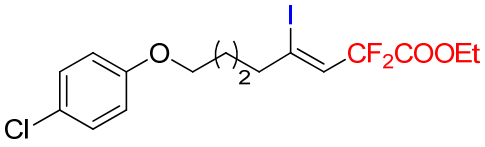
^{1}H NMR (400 MHz, $CDCl_3$) δ 6.36 (t, *J* = 14.4 Hz, 1H), 4.17-4.02 (m, 2H), 2.77-2.59 (m, 2H), 2.37-2.25 (m, 2H), 1.73-1.58 (m, 6H), 1.34-1.20 (m, 16H), 0.92-0.83 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.8, 126.9 (t, *J* = 23.5 Hz), 121.9, 120-100 (m), 63.5, 40.5, 34.3, 31.9, 29.6, 29.5, 29.4, 29.3, 29.2, 29.1, 27.3, 26.5, 25.0, 22.6, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.0 (m, 3F), -105.6 (m, 2F), -124.2 (m, 2F), -125.8 (m, 2F); HRMS: m/z (ESI) calculated $[M+H]^+$: 627.1382, measured: 627.1381.



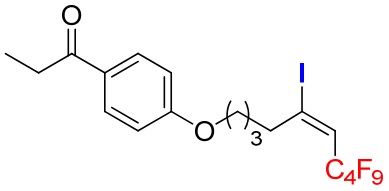
^{1}H NMR (400 MHz, $CDCl_3$) δ 6.27 (t, *J* = 13.2 Hz, 1H), 4.09 (t, *J* = 6.0 Hz, 2H), 2.77-2.66 (m, 2H), 2.30 (t, *J* = 7.6 Hz, 2H), 1.70-1.57 (m, 6H), 1.32-1.21 (m, 16H), 0.88 (t, *J* = 6.8 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.9, 122.1 (t, *J* = 23.5 Hz), 115.9, 120-100 (m), 63.5, 47.8, 34.3, 31.9, 29.7, 29.6, 29.4, 29.3, 29.2, 29.1, 27.0, 25.6, 25.0, 22.7, 14.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.0 (m, 3F), -108.8 (m, 2F), -123.8 (m, 2F), -125.8 (m, 2F); HRMS: m/z (ESI) calculated $[M+Na]^+$: 649.1201, measured: 649.1210.



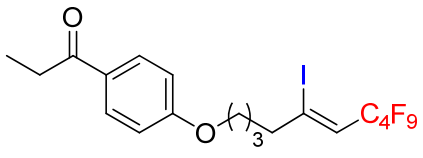
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.22 (d, *J* = 8.8 Hz, 2H), 6.82 (d, *J* = 8.8 Hz, 2H), 6.44 (t, *J* = 12.8 Hz, 1H), 4.33 (q, *J* = 7.2 Hz, 2H), 3.97-3.89 (m, 2H), 2.69 (t, *J* = 6.4 Hz, 2H), 1.83-1.67 (m, 4H), 1.35 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.5, 131.7 (t, *J* = 26.8 Hz), 129.2, 125.4, 118.7, 115.7, 115.6, 111.5 (t, *J* = 255.0 Hz), 67.6, 63.4, 40.2, 27.7, 26.4, 13.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ -97.7 (s); HRMS: m/z (ESI) calculated $[M+H]^+$: 480.9855, measured: 480.9862.



^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29-7.14 (m, 2H), 6.87-6.70 (m, 2H), 6.42 (t, *J* = 11.6 Hz, 1H), 4.42-4.24 (m, 2H), 3.99-3.83 (m, 2H), 2.72-2.56 (m, 2H), 1.83-1.67 (m, 4H), 1.42-1.30 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.4, 129.3, 128.7 (t, *J* = 28.7Hz), 125.5, 115.7, 114.4, 114,1 (t, *J* = 9.4 Hz), 112.0 (t, *J* = 246.4 Hz), 67.6, 63.3, 46.3, 27.5, 25.6, 13.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ -98.0 (s); HRMS: m/z (ESI) calculated $[M+Na]^+$: 480.9855, measured: 480.9850.

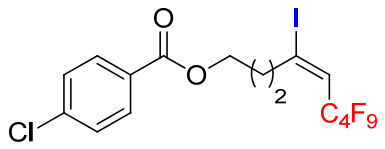


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, *J* = 8.8 Hz, 2H), 6.92 (d, *J* = 8.8 Hz, 2H), 6.37 (t, *J* = 14.4 Hz, 1H), 4.05 (t, *J* = 6.0 Hz, 2H), 2.96 (q, *J* = 7.2 Hz, 2H), 2.79-2.69 (m, 2H), 1.93-1.74 (m, 4H), 1.21 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.3, 162.6, 130.1, 129.9, 126.8 (t, *J* = 23.5 Hz), 122.0, 114.0, 120-100 (m), 67.4, 40.5, 31.3, 27.7, 26.5, 8.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.2 (m, 3F), -105.5 (t, *J* = 11.7 Hz, 2F), -124.2 (m, 2F), -125.9 (m, 2F); HRMS: m/z (ESI) calculated $[M+H]^+$: 577.0286, measured: 577.0280.

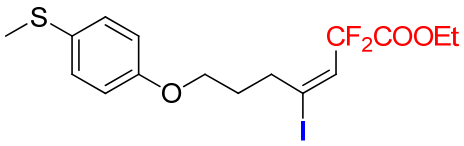


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 (d, *J* = 8.8 Hz, 2H), 6.92 (d, *J* = 8.8 Hz, 2H), 6.30 (t, *J* = 12.8 Hz, 1H), 4.15-4.00 (m, 2H), 2.96 (q, *J* = 7.2 Hz, 2H), 2.84-2.71 (m, 2H), 1.90-1.77 (m, 4H), 1.21 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.5, 162.6, 130.2, 130.0, 122.1 (t, *J* = 23.5 Hz), 115.9 (t, *J* = 6.0 Hz), 114.1, 120-100 (m), 67.5, 47.9, 31.4, 27.5, 25.8, 8.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.0 (t, *J* = 9.4 Hz,

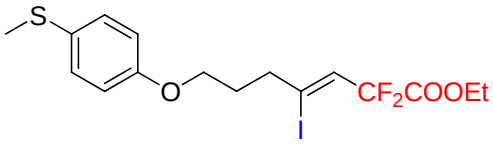
3F), -108.8 (t, J = 11.7 Hz, 2F), -123.8 (m, 2F), -125.8 (m, 2F); HRMS: m/z (ESI) calculated $[M+H]^+$: 577.0286, measured: 577.0223.



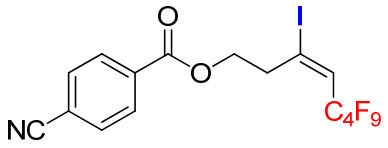
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 (d, J = 8.8 Hz, 2H), 7.42 (d, J = 8.8 Hz, 2H), 6.39 (t, J = 14.4 Hz, 1H), 4.36 (t, J = 6.0 Hz, 2H), 2.85 (t, J = 7.6 Hz, 2H), 2.14-2.02 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 139.5, 130.9, 128.7, 128.4, 127.3 (t, J = 23.8 Hz), 120.7 (t, J = 6.7 Hz), 120-100 (m), 63.4, 38.0, 29.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.1(t, J = 9.4 Hz, 3F), -105.8 (t, J = 14.3 Hz, 2F), -124.1 (m, 2F), -125.9 (m, 2F); HRMS: m/z (ESI) calculated $[M+Na]^+$: 590.9246, measured: 590.9293.
Z product: ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.0 (t, J = 9.4 Hz, 3F), -108.9 (t, J = 12.4 Hz, 2F), -123.8 (m, 2F), -125.8 (m, 2F); LRMS: m/z (EI) 441 (M-I), 285, 157, 139 (100), 127, 111.



^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26 (d, J = 8.0 Hz, 2H), 6.84 (d, J = 8.0 Hz, 2H), 6.46 (t, J = 13.2 Hz, 1H), 4.30 (q, J = 7.2 Hz, 2H), 3.96 (t, J = 6.4 Hz, 2H), 2.83 (t, J = 7.2 Hz, 2H), 2.44 (s, 3H), 2.10-1.98 (m, 2H), 1.34 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.2, 131.9 (t, J = 26.8 Hz), 129.9, 128.7, 117.7 (t, J = 7.4 Hz), 115.1, 114.0, 111.4 (t, J = 252.3 Hz), 66.2, 63.4, 37.5, 29.4, 17.9, 13.8; ^{19}F NMR (376 MHz, $CDCl_3$) δ -97.7 (s); HRMS: m/z (ESI) calculated $[M+Na]^+$: 478.9966, measured: 478.9955.

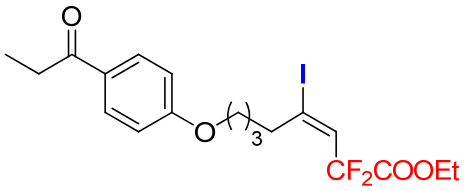


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26 (d, J = 8.8 Hz, 2H), 6.84 (d, J = 8.8 Hz, 2H), 6.44 (t, J = 11.6 Hz, 1H), 4.34 (q, J = 7.2 Hz, 2H), 3.94 (t, J = 6.0 Hz, 2H), 2.81 (t, J = 6.4 Hz, 2H), 2.44 (s, 3H), 2.11-1.97 (m, 2H), 1.35 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.2, 130.0, 129.1 (t, J = 29.5 Hz), 129.0, 116.4, 115.1, 113.1, 111.9 (t, J = 245.4 Hz), 65.6, 63.3, 43.2, 28.5, 17.9, 13.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ -98.1(s); HRMS: m/z (ESI) calculated $[M+Na]^+$: 478.9966, measured: 478.9972.

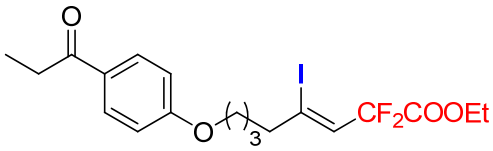


^{1}H NMR (400 MHz, $CDCl_3$) δ 8.13 (d, *J* = 8.0 Hz, 2H), 7.75 (d, *J* = 8.0 Hz, 2H), 6.54 (t, *J* = 14.0 Hz, 1H), 4.58 (t, *J* = 6.0 Hz, 2H), 3.17 (d, *J* = 6.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.5, 133.4, 132.2, 130.1, 129.3 (t, *J* = 23.5 Hz), 117.8, 116.6, 115.7 (t, *J* = 5.6 Hz), 120-100 (m), 63.8, 39.7; ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.1 (t, *J* = 9.4 Hz, 3F), -105.5 (t, *J* = 12.4 Hz, 2F), -124.1 (m, 2F), -125.8 (m, 2F); HRMS: m/z (ESI) calculated $[M+Na]^+$: 567.9432, measured: 567.9432.

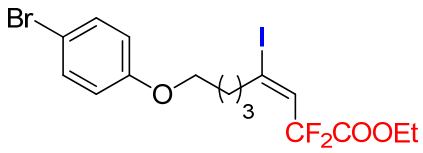
Z product: ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.0 (t, *J* = 9.4 Hz, 3F), -109.4 (t, *J* = 12.4 Hz, 2F), -123.8 (m, 2F), -125.8 (m, 2F); LRMS: m/z (EI) 418 (M-I), 130 (100), 127, 102, 69.



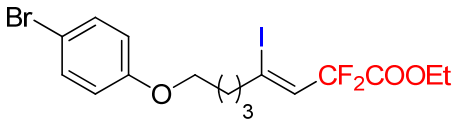
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, *J* = 8.4 Hz, 2H), 6.92 (d, *J* = 8.4 Hz, 2H), 6.45 (t, *J* = 13.2 Hz, 1H), 4.33 (q, *J* = 7.2 Hz, 2H), 4.04 (t, *J* = 6.0 Hz, 2H), 2.95 (q, *J* = 7.2 Hz, 2H), 2.71 (t, *J* = 6.4 Hz, 2H), 1.89-1.70 (m, 4H), 1.35 (t, *J* = 7.2 Hz, 3H), 1.21 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.2, 163.0 (t, *J* = 34.2Hz), 162.6, 131.7 (t, *J* = 26.8Hz), 130.0, 129.8, 118.5 (t, *J* = 7.8Hz), 114.0, 111.4 (t, *J* = 251.0 Hz), 67.4, 63.3, 40.0, 31.2, 27.6, 26.2, 13.8, 8.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ -97.6 (s); HRMS: m/z (ESI) calculated $[M+H]^+$: 481.0688, measured: 481.0696.



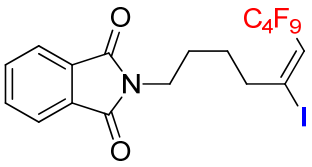
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 (d, *J* = 8.4 Hz, 2H), 6.92 (d, *J* = 8.4 Hz, 2H), 6.43 (t, *J* = 11.6 Hz, 1H), 4.36 (q, *J* = 7.2 Hz, 2H), 4.10-4.00 (m, 2H), 2.96 (q, *J* = 7.2 Hz, 2H), 2.74-2.64 (m, 2H), 1.87-1.72 (m, 4H), 1.37 (t, *J* = 7.2 Hz, 3H), 1.22 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.4, 162.6, 162.5 (t, *J* = 34.2 Hz), 130.2, 130.0, 128.7 (t, *J* = 28.9 Hz), 114.1, 114.0, 112.0 (t, *J* = 246.3Hz), 67.5, 63.3, 46.2, 31.4, 27.4, 25.5, 13.9, 8.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ -98.0 (s); HRMS: m/z (ESI) calculated $[M+H]^+$: 481.0688, measured: 481.0699.



^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 (d, *J* = 8.8 Hz, 2H), 6.78 (d, *J* = 8.8 Hz, 2H), 6.44 (t, *J* = 13.2 Hz, 1H), 4.33 (q, *J* = 7.2 Hz, 2H), 3.93 (t, *J* = 6.4 Hz, 2H), 2.69 (q, *J* = 6.4 Hz, 2H), 1.85-1.66 (m, 4H), 1.35 (t, *J* = 7.2 Hz, 3H), 1.21 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.0 (t, *J* = 33.8Hz), 157.9, 132.1, 131.7 (t, *J* = 26.8 Hz), 118.7 (t, *J* = 7.4Hz), 116.2, 112.6, 111.4 (t, *J* = 250.5Hz), 67.5, 63.4, 40.1, 27.7, 26.3, 13.8; ^{19}F NMR (376 MHz, $CDCl_3$) δ -97.6 (s); HRMS: m/z (ESI) calculated $[M+Na]^+$: 524.9350, measured: 524.9343.

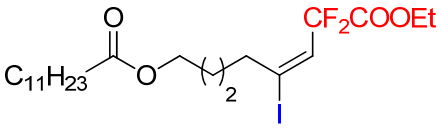


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37(d, *J* = 8.4 Hz, 2H), 6.77 (d, *J* = 8.4 Hz, 2H), 6.43 (t, *J* = 11.2 Hz, 1H), 4.36 (q, *J* = 7.2 Hz, 2H), 3.99-3.86 (m, 2H), 2.75-2.59 (m, 2H), 1.83-1.69 (m, 4H), 1.37 (t, *J* = 7.2 Hz, 3H), 1.21 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.2, 157.9, 132.2, 128.7 (t, *J* = 29.1Hz), 116.2, 114.1 (t, *J* = 9.8Hz), 112.8, 112.0 (t, *J* = 243.9Hz), 67.5, 63.3, 46.3, 27.5, 25.6, 13.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ -98.0 (s); HRMS: m/z (ESI) calculated $[M+Na]^+$: 524.9350, measured: 524.9324.

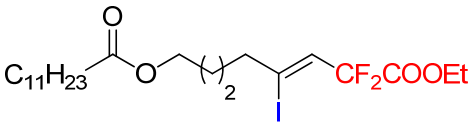


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90-7.83 (m, 2H), 7.77-7.70 (m, 2H), 6.34 (t, *J* = 14.4 Hz, 1H), 3.72 (t, *J* = 7.2 Hz, 2H), 2.77-2.63 (m, 2H), 1.80-1.60 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.2, 133.8, 132.0, 126.9 (t, *J* = 23.4 Hz), 123.1, 121.8, 120-100 (m), 40.2, 37.4, 27.1, 27.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.2(t, *J* = 9.0 Hz, 3F), -105.6 (t, *J* = 12.0 Hz, 2F), -124.2 (m, 2F), -125.9 (m, 2F); HRMS: m/z (ESI) calculated $[M+Na]^+$: 595.9745, measured: 595.9846.

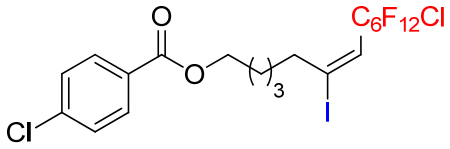
Z product: ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.0 (m, 3F), -108.8 (m, 2F), -123.8 (m, 2F), -125.8 (m, 2F); HRMS: m/z (ESI) calculated $[M+Na]^+$: 595.9745, measured: 595.9846.



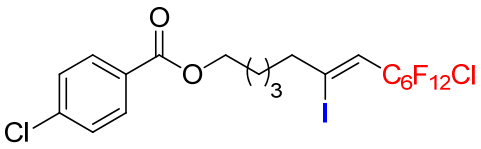
^{1}H NMR (400 MHz, $CDCl_3$) δ 6.43 (t, *J* = 13.2 Hz, 1H), 4.34 (q, *J* = 7.2 Hz, 2H), 4.16-4.04 (m, 2H), 2.75-2.60 (m, 2H), 2.31 (t, *J* = 7.2 Hz, 2H), 1.70-1.56 (m, 6H), 1.42-1.19 (m, 19H), 0.88 (t, *J* = 6.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.7, 163.0, 131.7 (t, *J* = 26.9Hz), 118.5 (t, *J* = 7.3Hz), 111.4 (t, *J* = 251.0Hz), 63.6, 63.3, 40.1, 34.2, 31.8, 29.6, 29.5, 29.4, 29.3, 29.2, 29.1, 27.2, 26.2, 24.9, 22.6, 14.0, 13.8; ^{19}F NMR (376 MHz, $CDCl_3$) δ -97.7(s); HRMS: m/z (ESI) calculated $[M+H]^+$: 531.1783, measured: 531.1777.



^{1}H NMR (400 MHz, $CDCl_3$) δ 6.41 (t, *J* = 11.6 Hz, 1H), 4.36 (q, *J* = 7.2 Hz, 2H), 4.14-4.04 (m, 2H), 2.68-2.59 (m, 2H), 2.30 (t, *J* = 7.2 Hz, 2H), 1.70-1.57 (m, 6H), 1.41-1.19 (m, 19H), 0.88 (t, *J* = 6.8 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.9, 161.8, 128.7 (t, *J* = 28.8Hz), 114.0 (t, *J* = 6.2Hz), 112.0 (t, *J* = 246.3Hz), 63.5, 63.3, 46.1, 34.3, 31.9, 29.6, 29.5, 29.4, 29.3, 29.2, 29.1, 27.0, 25.4, 25.0, 22.7, 14.1, 13.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ -98.0 (s); HRMS: m/z (ESI) calculated $[M+H]^+$: 531.1783, measured: 531.1776.

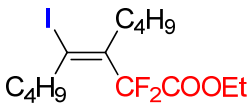


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.4 Hz, 2H), 7.41 (d, *J* = 8.4 Hz, 2H), 6.35 (t, *J* = 14.4 Hz, 1H), 4.33 (t, *J* = 6.4 Hz, 2H), 2.67 (q, *J* = 7.2 Hz, 2H), 1.85-1.76 (m, 2H), 1.72-1.62 (m, 2H), 1.54-1.44 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 139.3, 130.9, 128.8, 128.7, 126.9 (t, *J* = 24.2Hz), 122.2, 120-100 (m), 64.9, 40.8, 29.6, 28.4, 24.8; ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.0 (t, *J* = 13.9 Hz, 2F), -105.3 (t, *J* = 13.5 Hz, 2F), -120.1 (m, 2F), -121.3 (m, 2F), -121.5 (m, 2F), -123.2 (m, 2F); LRMS: m/z (EI) 429, 409, 157, 139 (100), 127, 111.



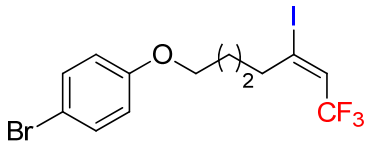
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.4 Hz, 2H), 7.41 (d, *J* = 8.4 Hz, 2H), 6.26 (t, *J* = 13.2 Hz, 1H), 4.33 (t, *J* = 6.4 Hz, 2H), 2.70 (q, *J* = 7.2 Hz, 2H), 1.85-1.76 (m, 2H), 1.73-1.63 (m, 2H), 1.51-1.41 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 139.4, 130.9, 128.7, 128.6, 122.0 (t, *J* = 23.5 Hz), 116.0 (t, *J* = 6.0 Hz), 120-100 (m), 64.8, 48.1, 28.7, 28.3, 24.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.0 (t, *J* = 13.9 Hz, 2F), -108.5 (t, *J* = 13.5 Hz, 2F), -120.1 (m, 2F), -121.2 (m, 2F), -121.4 (m, 2F), -122.8 (m,

2F); LRMS: m/z (EI) 429, 409, 207, 157, 139 (100), 127, 111.

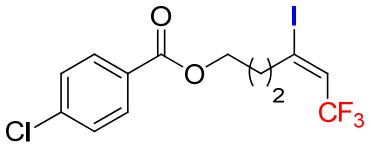


^{1}H NMR (400 MHz, $CDCl_3$) δ 4.44-4.26 (m, 2H), 2.76-2.61 (m, 2H), 2.52-2.37 (m, 2H), 1.59-1.43 (m, 4H), 1.40-1.25 (m, 7H), 1.01-0.84 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.6 (t, *J* = 34.9Hz), 136.5 (t, *J* = 22.5Hz), 119.5 (t, *J* = 6.1Hz), 111.9 (t, *J* = 254.3Hz), 63.1, 42.5, 39.0, 32.6, 30.1, 22.6, 21.7, 13.9, 13.8, 13.7; ^{19}F NMR (376 MHz, $CDCl_3$) δ -96.6 (s); HRMS: m/z (ESI) calculated $[M+Na]^+$: 411.0608, measured: 411.0595.

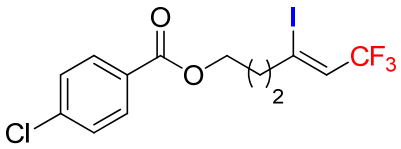
Z product: ^{19}F NMR (376 MHz, $CDCl_3$) δ -98.0 (s); LRMS: m/z (EI) 261 (M-I), 233, 157, 127 (100), 111, 91, 55.



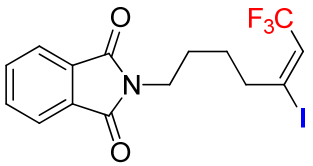
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 (d, *J* = 8.8 Hz, 2H), 6.78 (d, *J* = 8.8 Hz, 2H), 6.44 (q, *J* = 7.6 Hz, 1H), 3.94 (t, *J* = 7.2 Hz, 2H), 2.69 (t, *J* = 7.6 Hz, 2H), 1.86-1.70 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.0, 132.2, 129.5 (q, *J* = 34.2 Hz), 121.8 (q, *J* = 272.5 Hz), 120.1 (t, *J* = 6.0 Hz), 116.2, 112.8, 67.5, 40.2, 27.7, 26.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ -57.7 (s); HRMS: m/z (APCI) calculated $[M]^+$: 447.9147, measured: 447.9141.



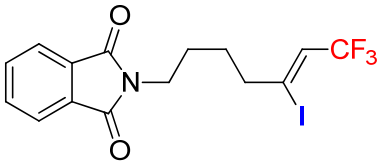
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.4 Hz, 2H), 7.43 (d, *J* = 8.4 Hz, 2H), 6.46 (q, *J* = 7.6 Hz, 1H), 4.35 (t, *J* = 6.0 Hz, 2H), 2.83 (t, *J* = 7.2 Hz, 2H), 2.07 (tt, *J* = 7.2, 6.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 139.4, 130.9, 129.9 (q, *J* = 34.2 Hz), 128.7, 128.4, 121.6 (q, *J* = 272.5 Hz), 118.5 (q, *J* = 6.1 Hz), 63.3, 37.5, 28.7; ^{19}F NMR (376 MHz, $CDCl_3$) δ -57.9 (s); HRMS: m/z (APPI) calculated $[M+H]^+$: 418.9523, measured: 418.9520.



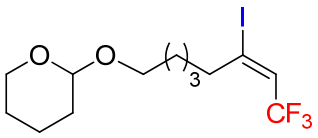
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.0 Hz, 2H), 7.43 (d, *J* = 8.0 Hz, 2H), 6.38 (q, *J* = 6.4 Hz, 1H), 4.35 (t, *J* = 7.2 Hz, 2H), 2.79 (t, *J* = 8.4 Hz, 2H), 2.08 (tt, *J* = 8.4, 7.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 139.6, 131.0, 128.8, 128.4, 125.9 (q, *J* = 35.5 Hz), 125.7, 121.4 (q, *J* = 254.8 Hz), 63.2, 43.6, 29.7; ^{19}F NMR (376 MHz, $CDCl_3$) δ -60.2 (s); LRMS: m/z (EI) 291 (M-I), 157, 139 (100), 127, 111, 75.



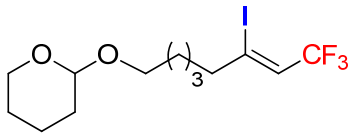
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98-7.80 (m, 2H), 7.78-7.62 (m, 2H), 6.41 (q, *J* = 7.2 Hz, 1H), 3.82-3.56 (m, 2H), 2.75-2.52 (m, 2H), 1.82-1.47 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.3, 133.9, 132.0, 129.5 (q, *J* = 34.2 Hz), 123.2, 121.6 (q, *J* = 247.7 Hz), 119.8 (q, *J* = 6.0 Hz), 39.8, 37.4, 27.1, 26.8; ^{19}F NMR (376 MHz, $CDCl_3$) δ -57.7 (s); HRMS: m/z (ESI) calculated $[M+H]^+$: 424.0021, measured: 424.0022.



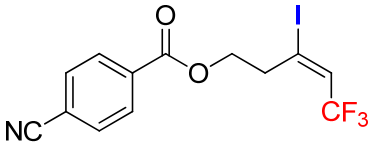
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92-7.81 (m, 2H), 7.78-7.68 (m, 2H), 6.34 (q, *J* = 7.2 Hz, 1H), 3.72 (t, *J* = 6.4 Hz, 2H), 2.66 (t, *J* = 6.4 Hz, 2H), 1.75-1.57 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.4, 134.0, 132.0, 125.4 (q, *J* = 35.6Hz), 123.3, 121.2 (q, *J* = 269.1Hz), 115.0 (q, *J* = 6.0 Hz), 46.0, 37.3, 27.0, 26.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ -60.1 (s); HRMS: m/z (ESI) calculated $[M+H]^+$: 424.0021, measured: 424.0027.



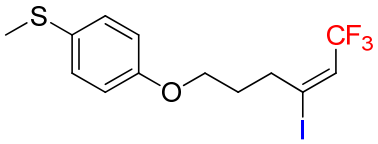
^{1}H NMR (400 MHz, $CDCl_3$) δ 6.39 (q, *J* = 7.6 Hz, 1H), 4.59 (dd, *J* = 4.4, 2.4 Hz, 1H), 3.93-3.82 (m, 1H), 3.75 (dt, *J* = 9.6, 6.4 Hz, 1H), 3.56-3.46 (m, 1H), 3.39 (dt, *J* = 9.6, 6.4 Hz, 1H), 2.62 (t, *J* = 7.2 Hz, 2H), 1.88-1.78 (m, 1H), 1.77-1.68 (m, 1H), 1.66-1.50 (m, 8H), 1.46-1.37 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 129.0 (q, *J* = 34.3 Hz), 121.8 (q, *J* = 272.5 Hz), 120.6 (q, *J* = 6.0 Hz), 98.8, 67.2, 62.2, 40.7, 30.7, 29.4, 29.3, 25.4, 25.1, 19.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ -57.8 (s); HRMS: m/z (ESI) calculated $[M+Na]^+$: 415.0358, measured: 415.0353.



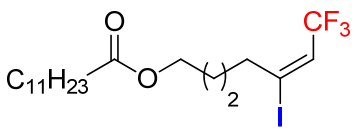
^{1}H NMR (400 MHz, $CDCl_3$) δ 6.30 (q, *J* = 7.2 Hz, 1H), 4.58 (dd, *J* = 4.4, 2.0 Hz, 1H), 3.91-3.82 (m, 1H), 3.75 (dt, *J* = 9.6, 6.8 Hz, 1H), 3.56-3.46 (m, 1H), 3.39 (dt, *J* = 9.6, 6.4 Hz, 1H), 2.62 (t, *J* = 7.2 Hz, 2H), 1.88-1.77 (m, 1H), 1.76-1.68 (m, 1H), 1.66-1.49 (m, 8H), 1.43-1.36 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 124.9 (q, *J* = 35.6 Hz), 121.4 (q, *J* = 269.1 Hz), 115.9, 98.9, 67.2, 62.4, 46.8, 30.7, 29.3, 28.8, 25.4, 24.8, 19.7; ^{19}F NMR (376 MHz, $CDCl_3$) δ -60.0 (s); HRMS: m/z (ESI) calculated $[M+Na]^+$: 415.0358, measured: 415.0349.



^{1}H NMR (400 MHz, $CDCl_3$) δ 8.13 (d, *J* = 8.0 Hz, 2H), 7.76 (d, *J* = 8.0 Hz, 2H), 6.59 (q, *J* = 7.6 Hz, 1H), 4.56 (t, *J* = 7.2 Hz, 2H), 3.14 (t, *J* = 7.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.5, 133.4, 132.2, 131.8 (q, *J* = 34.2 Hz), 130.1, 121.6 (q, *J* = 272.4 Hz), 117.8, 116.5, 113.7 (q, *J* = 6.0 Hz), 63.4, 39.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ -57.7 (s); LRMS: m/z (EI) 268 (M-I), 130 (100), 127, 121, 102, 75.
Z product: ^{19}F NMR (376 MHz, $CDCl_3$) δ -60.6 (s); LRMS: m/z (EI) 268 (M-I), 130 (100), 127, 121, 102, 75.

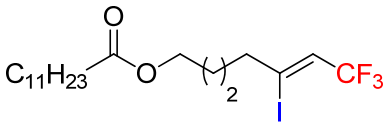


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26 (d, *J* = 8.4 Hz, 2H), 6.83 (d, *J* = 8.4 Hz, 2H), 6.45 (q, *J* = 7.2 Hz, 1H), 3.96 (t, *J* = 6.0 Hz, 2H), 2.84 (t, *J* = 6.4 Hz, 2H), 2.44 (s, 3H), 2.14-2.01 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.2, 130.0, 129.8 (q, *J* = 34.3 Hz), 129.0, 121.8 (q, *J* = 272.5 Hz), 119.1 (q, *J* = 6.1 Hz), 115.1, 66.0, 37.5, 29.3, 17.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ -57.9 (s); HRMS: m/z (ESI) calculated $[M+K]^+$: 440.9399, measured: 440.9635.

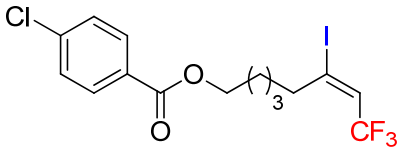


^{1}H NMR (400 MHz, $CDCl_3$) δ 6.43 (q, *J* = 7.2 Hz, 1H), 4.17-4.00 (m, 2H), 2.71-2.58 (m, 2H), 2.36-2.27 (m, 2H), 1.71-1.57 (m, 6H), 1.37-1.18 (m, 16H), 0.92-0.83 (m,

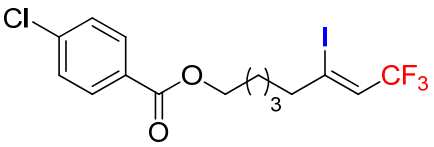
3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.7, 129.5(q, *J* = 34.2Hz), 121.8 (q, *J* = 271.8Hz), 119.8 (q, *J* = 6.0 Hz), 63.5, 40.1, 34.2, 31.9, 29.6, 29.5, 29.4, 29.3, 29.2, 29.1, 27.2, 26.0, 24.9, 22.6, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ -57.8 (s); HRMS: m/z (ESI) calculated $[M+H]^+$: 477.1477, measured: 477.1490.



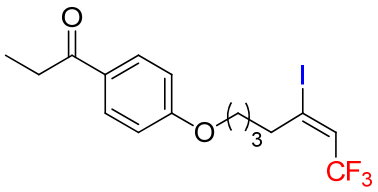
^{1}H NMR (400 MHz, $CDCl_3$) δ 6.33 (q, *J* = 7.2 Hz, 1H), 4.17-3.99 (m, 2H), 2.75-2.54 (m, 2H), 2.38-2.23 (m, 2H), 1.72-1.52 (m, 6H), 1.38-1.13 (m, 16H), 0.95-0.80 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.9, 125.3 (q, *J* = 35.6 Hz), 121.2 (q, *J* = 269.7 Hz), 115.2 (q, *J* = 5.6 Hz), 63.5, 46.3, 34.3, 31.9, 29.7, 29.6, 29.5, 29.3, 29.2, 29.1, 27.1, 25.5, 25.0, 22.7, 14.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ -60.1 (s); HRMS: m/z (ESI) calculated $[M+Na]^+$: 499.1297, measured: 499.1287.



^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 7.6 Hz, 2H), 7.42 (d, *J* = 7.6 Hz, 2H), 6.41 (q, *J* = 7.6 Hz, 1H), 4.32 (t, *J* = 6.4 Hz, 2H), 2.64 (t, *J* = 4.4 Hz, 2H), 1.86-1.76 (m, 2H), 1.70-1.61 (m, 2H), 1.53-1.44 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 139.3, 130.9, 129.3 (q, *J* = 34.2 Hz), 128.8, 128.7, 121.8 (q, *J* = 272.5 Hz), 120.2 (q, *J* = 6.1 Hz), 64.9, 40.4, 29.2, 28.3, 24.7; ^{19}F NMR (376 MHz, $CDCl_3$) δ -57.7 (s); HRMS: m/z (APPI) calculated $[M+H]^+$: 446.9836, measured: 446.9830.

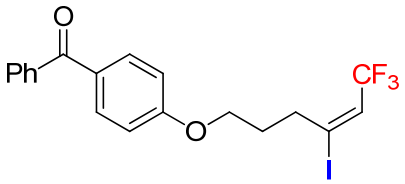


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.0 Hz, 2H), 7.42 (d, *J* = 8.0 Hz, 2H), 6.31 (q, *J* = 7.2 Hz, 1H), 4.33 (t, *J* = 6.4 Hz, 2H), 2.64 (t, *J* = 6.0 Hz, 2H), 1.85-1.75 (m, 2H), 1.71-1.63 (m, 2H), 1.50-1.41 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 139.4, 130.9, 128.9, 128.8, 125.2 (q, *J* = 35.5 Hz), 121.3 (q, *J* = 269.8 Hz), 115.5 (q, *J* = 6.0 Hz), 64.8, 46.4, 28.6, 28.3, 24.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ -60.1 (s); HRMS: m/z (APPI) calculated $[M+H]^+$: 446.9836, measured: 446.9840.

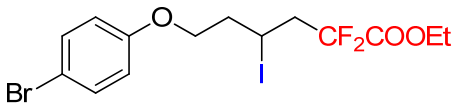


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, *J* = 8.0 Hz, 2H), 6.92 (d, *J* = 8.0 Hz, 2H), 6.44 (q, *J* = 7.2 Hz, 1H), 4.15-3.96 (m, 2H), 3.06-2.87 (m, 2H), 2.80-2.63 (m, 2H), 1.94-1.70 (m, 4H), 1.34-1.13 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.5, 162.6, 130.2, 130.1, 129.6 (q, *J* = 34.2 Hz), 124.5 (q, *J* = 273.2Hz), 119.9 (q, *J* = 6.1 Hz), 111.1, 67.4, 40.1, 31.4, 27.6, 26.1, 8.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ -57.7 (s); HRMS: m/z (ESI) calculated $[M+H]^+$: 427.0382, measured: 427.0385.

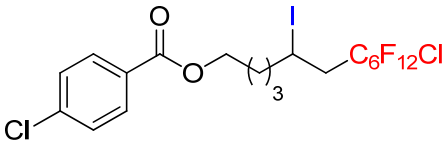
Z product: ^{19}F NMR (376 MHz, $CDCl_3$) δ -60.1(s); HRMS: m/z (ESI) calculated $[M+H]^+$: 427.0382, measured: 427.0399.



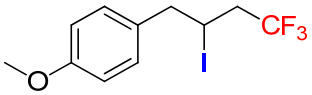
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, *J* = 8.8 Hz, 2H), 7.76 (d, *J* = 7.6 Hz, 2H), 7.57 (t, *J* = 7.6 Hz, 1H), 7.48 (dd, *J* = 7.6, 7.6 Hz, 2H), 6.95 (d, *J* = 8.8 Hz, 2H), 6.47 (q, *J* = 7.6 Hz, 1H), 4.07 (t, *J* = 6.0 Hz, 2H), 2.87 (t, *J* = 7.2 Hz, 2H), 2.12 (tt, *J* = 7.2, 6.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 195.5, 162.3, 138.2, 132.5, 131.9, 130.2, 130.0 (q, *J* = 34.2 Hz), 129.7, 128.2, 121.8 (q, *J* = 272.5 Hz), 118.8 (q, *J* = 5.3Hz), 113.9, 66.0, 37.4, 29.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ -57.9 (s); HRMS: m/z (ESI) calculated $[M+H]^+$: 461.0226, measured: 461.0229.



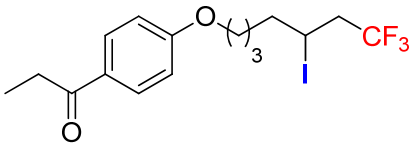
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (d, *J* = 8.0 Hz, 2H), 6.81 (d, *J* = 8.0 Hz, 2H), 4.54-4.44 (m, 1H), 4.38 (q, *J* = 7.2 Hz, 2H), 4.18-4.02 (m, 2H), 3.13-2.96 (m, 1H), 2.95-2.78 (m, 1H), 2.37-2.13 (m, 2H), 1.40 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.2 (t, *J* = 32.2 Hz), 157.5, 132.2, 116.3, 115.0 (q, *J* = 251.6 Hz), 113.1, 67.6, 63.2, 45.3 (q, *J* = 23.1 Hz), 39.3, 18.4, 13.8; ^{19}F NMR (376 MHz, $CDCl_3$) δ -101.8 (d, *J* = 264.0 Hz, 1F), -106.3 (d, *J* = 264.0 Hz, 1F); HRMS: m/z (ESI) calculated $[M+Na]^+$: 498.9193, measured: 498.9215.



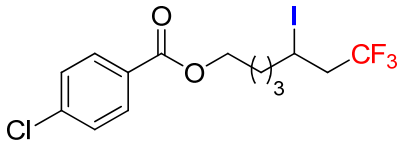
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (d, *J* = 8.8 Hz, 2H), 7.41 (d, *J* = 8.8 Hz, 2H), 4.40-4.27 (m, 3H), 3.05-2.70 (m, 2H), 1.97-1.68 (m, 5H), 1.65-1.53 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 139.4, 130.9, 128.7, 128.6, 120-100 (m), 64.6, 41.6 (t, *J* = 20.8Hz), 39.6, 27.6, 26.2, 20.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.0 (t, *J* = 13.5Hz, 2F), -111.5 (dt, *J* = 269.6, 14.7Hz, 1F), -114.6 (dt, *J* = 269.6, 12.8 Hz, 1F), -120.1 (m, 2F), -121.3 (m, 2F), -121.6 (m, 2F), -123.6 (m, 2F); LRMS: m/z (EI) 417, 157, 139 (100), 127, 111, 81.



^{1}H NMR (400 MHz, $CDCl_3$) δ 7.11 (d, *J* = 8.4 Hz, 2H), 6.87 (d, *J* = 8.4 Hz, 2H), 4.39-4.24 (m, 1H), 3.81 (s,3H), 3.25-3.12 (m, 2H), 2.93-2,74 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.7, 130.6, 130.0, 125.6 (q, *J* = 276.5Hz), 113.9, 55.2, 45.8, 43.5 (q, *J* = 28.2 Hz), 21.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ -63.6 (s); LRMS: m/z (EI) 344 (M), 217 (M-I, 100), 134, 127, 121, 91, 77.

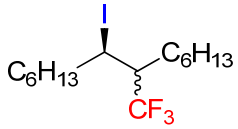


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 (d, *J* = 8.4 Hz, 2H), 6.82 (d, *J* = 8.4 Hz, 2H), 4.29-4.18 (m, 1H), 4.05 (t, *J* = 6.0 Hz, 2H), 3.02-2.73 (m, 4H), 1,96-1,56 (m, 6H), 1.21 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.4, 162.6, 130.2, 129.9, 125.5 (q, *J* = 277.2Hz), 114.0, 67.6, 44.8 (q, *J* = 28.2 Hz), 39.2, 31.3, 28.0, 26.2, 21.2, 8.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ -63.9 (s); HRMS: m/z (ESI) calculated $[M+H]^+$: 429.0538, measured: 429.0548.

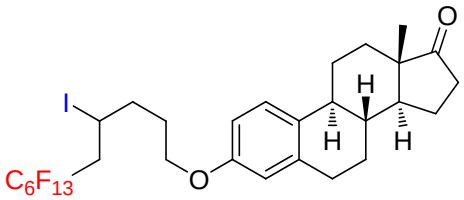


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (d, *J* = 8.8 Hz, 2H), 7.42 (d, *J* = 8.8 Hz, 2H), 4.42-4.30 (m, 2H), 4.28-4.17 (m, 1H), 3.05-2.72 (m, 2H), 1,95-1,52 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 139.3, 130.9, 128.7, 125.5 (q, *J* = 277.1Hz), 114.9, 64.6, 44.9 (q, *J* = 28.2 Hz), 39.0, 27.6, 26.1, 21.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ

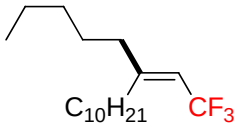
-63.9 (s); HRMS: m/z (ESI) calculated $[M+Na]^+$: 456.9655, measured: 456.9665.



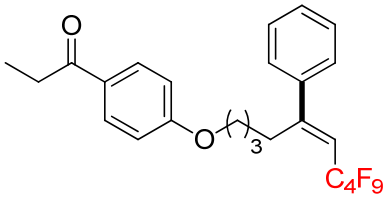
^{1}H NMR (400 MHz, $CDCl_3$) δ [4.36 (d, *J* = 11.2 Hz), 4.31-4.24] (1H), [2.54-2.42 (m)] (0.5H), [2.08-1.90 (m)] (1H), [1.87-1.62 (m)] (2.5H), [1.61-1.43 (m)] (3H), [1,42-1,21 (m)] (14H), [0.96-0.84 (m)] (6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ [126.7 (q, *J* = 280.1Hz), 126.4 (q, *J* = 281.5 Hz)],[51.0 (q, *J* = 23.2 Hz), 48.6 (q, *J* = 24.5 Hz)], [38.9, 38.9], [35.7, 35.7], [32.8 (q, *J* = 2.4 Hz), 31.1 (q, *J* = 3.1 Hz)], [31.6, 31.5], [30.5, 30.5], [29.8, 29.8], [29.3, 29.3], [29.3, 29.1], [28.2, 28.2], [27.8, 27.7], [26.7, 26.7], [22.6, 22.5], [14.0, 14.0]; ^{19}F NMR (376 MHz, $CDCl_3$) δ [-65.4 (s), -67.1 (s)]; LRMS: m/z (EI) 265 (M-I), 127, 85, 71, 57 (100).



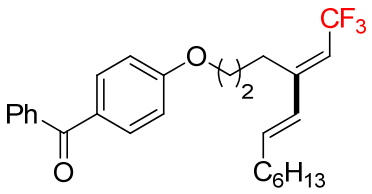
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (d, *J* = 8.8 Hz, 1H), 6.70 (dd, *J* = 8.8, 2.8 Hz, 1H), 6.63 (d, *J* = 2.8 Hz, 1H), 4.45-4.34 (m, 1H), 4.04-3.94 (m, 2H), 3.06-2.73 (m, 4H), 2.50 (dd, *J* = 18.4, 8.8 Hz, 1H), 2.43-2.36 (m, 1H), 2.30-2.21 (m, 1H), 2.20-1.83 (m, 8H), 1.69-1.36 (m, 1H), 0.91 (s, 3H),; ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.7, 137.6, 132.1, 126.2, 114.4, 111.9, 66.3, 50.3, 47.8, 43.9, 41.5 (t, *J* = 20.8 Hz), 38.2, 37.0, 35.7, 31.5, 29.5, 26.4, 25.8, 21.4, 19.9, 13.7; ^{19}F NMR (376 MHz, $CDCl_3$) δ -80.8 (t, *J* = 9.4 Hz, 3F), -111.7 (dm, *J* = 269.4 Hz, 1F), -114.4 (dt, *J* = 269.4, 13.9 Hz, 1F), -121.7 (m, 2F), -122.8 (m, 2F), -123.6 (m, 2F), -126.1 (m, 2F); HRMS: m/z (ESI) calculated $[M+H]^+$: 785.1161, measured: 785.1270.



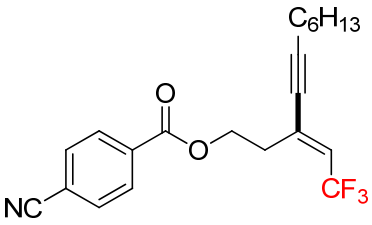
^{1}H NMR(400 MHz, $CDCl_3$) δ 5.37 (q, *J* = 8.8 Hz, 1H), 2.22 (td, *J* = 8.0, 1.2 Hz, 2H), 2.11-2.04 (m, 2H), 1.48-1.36 (m, 4H), 1.35-1.20 (m, 18H), 0.94-0.83 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.2, 123.8 (q, *J* = 269.1 Hz), 113.6 (q, *J* = 32.9 Hz), 36.3, 31.9, 31.5, 31.4, 29.7, 29.6, 29.5, 29.4, 29.3, 28.2, 27.1, 22.7, 22.5, 14.1, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ -56.4 (s); LRMS: m/z (EI) 306 (M), 180, 165, 126, 97, 83, 69, 56 (100).



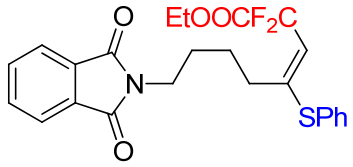
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 8.0 Hz, 2H), 7.45-7.30 (m, 5H), 6.84 (d, *J* = 8.0 Hz, 2H), 5.67 (t, *J* = 15.6 Hz, 1H), 3.94 (t, *J* = 5.2 Hz, 2H), 3.00-2.90 (m, 2H), 2.87-2.77 (m, 2H), 1.86-1.75 (m, 2H), 1.59-1.47 (m, 2H), 1.21 (t, *J* = 6.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.5, 162.6, 156.2, 140.4, 130.1, 129.8, 129.0, 128.7, 126.6, 114.2 (t, *J* = 22.1 Hz), 114.0, 120-100 (m), 67.5, 31.3, 30.8, 28.7, 24.9, 8.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ -81.0 (m, 3F), -105.0 (m, 2F), -124.2 (m, 2F), -125.6 (m, 2F); HRMS: m/z (ESI) calculated $[M+H]^+$: 527.1633, measured: 527.1630.



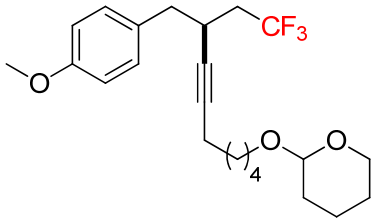
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 8.8 Hz, 2H), 7.75 (d, *J* = 7.6 Hz, 2H), 7.56 (t, *J* = 7.6 Hz, 1H), 7.47 (t, *J* = 7.6 Hz, 2H), 6.95 (d, *J* = 8.8 Hz, 2H), 6.09 (dt, *J* = 16.0, 6.8 Hz, 1H), 5.96 (d, *J* = 16.0 Hz, 1H), 5.52 (q, *J* = 8.8 Hz, 1H), 4.06 (t, *J* = 6.0 Hz, 2H), 6.63 (td, *J* = 8.0, 1.2 Hz, 2H), 2.13 (td, *J* = 7.2, 6.8 Hz, 2H), 2.05-1.95 (m, 2H), 1.44-1.34 (m, 2H), 1.32-1.21 (m, 6H), 0.88 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 195.5, 162.5, 149.4 (q, *J* = 5.4 Hz), 138.3, 136.6, 132.6, 131.9, 130.1, 129.7, 128.2, 123.9 (q, *J* = 268.4 Hz), 116.0 (q, *J* = 32.9 Hz), 113.9, 67.4, 32.9, 31.6, 28.9, 28.8, 24.3, 22.5, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ -56.3 (s); HRMS: m/z (ESI) calculated $[M+H]^+$: 445.2354, measured: 445.2346.



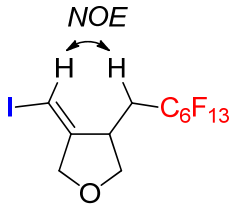
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.13 (d, *J* = 8.4 Hz, 2H), 7.74 (d, *J* = 8.4 Hz, 2H), 5.95 (q, *J* = 8.4 Hz, 1H), 4.58 (t, *J* = 6.4 Hz, 2H), 2.82 (t, *J* = 6.4 Hz, 2H), 2.30 (t, *J* = 7.2 Hz, 2H), 1.15 (tt, *J* = 7.6, 6.8 Hz, 2H), 1.40-1.32 (m, 2H), 1.31-1.22 (m, 4H), 0.88 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.7, 133.8, 132.8 (q, *J* = 5.4 Hz), 132.1, 130.1, 123.9 (q, *J* = 33.6 Hz), 122.7 (q, *J* = 268.4 Hz), 117.9, 116.4, 96.8, 78.5, 63.0, 31.6, 31.2, 28.5, 28.2, 22.4, 19.3, 13.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ -56.8 (s); LRMS: m/z (EI) 377 (M), 308 (M-CF_3), 201, 130 (100), 102, 91, 69.



^{1}H NMR(400 MHz, $CDCl_3$) δ 7.85 (dd, *J* = 5.2, 2.8 Hz, 2H), 7.71 (dd, *J* = 5.2, 2.8 Hz, 2H), 7.47-7.42 (m, 2H), 7.41-7.36 (m, 3H), 5.06 (t, *J* = 14.0 Hz, 1H), 4.25 (q, *J* = 7.2 Hz, 2H), 3.70 (t, *J* = 6.4 Hz, 2H), 2.52 (t, *J* = 6.4 Hz, 2H), 1.78-1.64 (m, 4H), 1.28 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.3, 153.8, 135.1, 133.8, 132.3, 132.1, 130.1, 129.7, 129.5, 123.2, 113.5 (t, *J* = 26.9 Hz), 112.5 (t, *J* = 248.3 Hz), 62.9, 37.6, 31.9, 28.1, 26.6, 13.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ -96.3 (s); HRMS: m/z (ESI) calculated $[M+Na]^+$: 482.1214, measured: 482.1211.

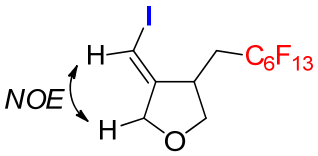


^{1}H NMR(400 MHz, $CDCl_3$) δ 7.13 (d, *J* = 8.4 Hz, 2H), 6.84 (d, *J* = 8.4 Hz, 2H), 4.57 (dd, *J* = 4.4, 2.4 Hz, 1H), 3.86 (ddd, *J* = 10.8, 7.2, 3.2 Hz, 1H), 3.79 (s, 3H), 3.73 (dtd, *J* = 9.6, 6.8, 1.2 Hz, 1H), 3.54-3.46 (m, 1H), 3.38 (dt, *J* = 9.6, 6.4 Hz, 1H), 2.94-2.84 (m, 1H), 2.76 (dd, *J* = 6.8, 4.8 Hz, 2H), 2.24-2.09 (m, 4H), 1.88-1.77 (m, 1H), 1.75-1.67 (m, 1H), 1.64-1.37 (m, 10H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 130.3, 130.2, 126.3 (q, *J* = 275.8 Hz), 113.6, 98.8, 83.2, 80.2, 67.4, 62.3, 55.2, 40.3, 38.2 (q, *J* = 27.5 Hz), 30.7, 29.2, 28.6, 27.8, 25.5, 25.4, 19.6, 18.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ -63.9 (s); HRMS: m/z (ESI) calculated $[M+Na]^+$: 435.2123, measured: 435.2132.

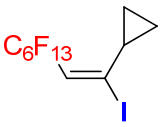


^{1}H NMR(400 MHz, $CDCl_3$) δ 6.13 (ddd, *J* = 2.8, 2.8, 2.0 Hz, 1H), 4.37-4.19 (m, 3H), 3.75 (dd, *J* = 8.8, 7.2 Hz, 1H), 3.16-3.06 (m, 1H), 2.50-2.31 (m, 1H), 2.30-2.12 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.8, 120-100 (m), 75.6, 74.8 (d, *J* = 4.0 Hz), 68.8, 39.4, 32.9 (t, *J* = 21.5 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ -80.8 (t, *J* = 10.1 Hz, 3F), -112.1 (dm, *J* = 270.0 Hz, 1F), -113.9 (dm, *J* = 270.0 Hz, 1F), -121.7 (m, 2F), -122.8 (m, 2F), -123.4 (m, 2F), -126.1 (m, 2F); HRMS: m/z (ESI) calculated $[M+Na]^+$:

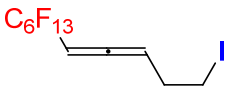
415.0368, measured: 415.0363.



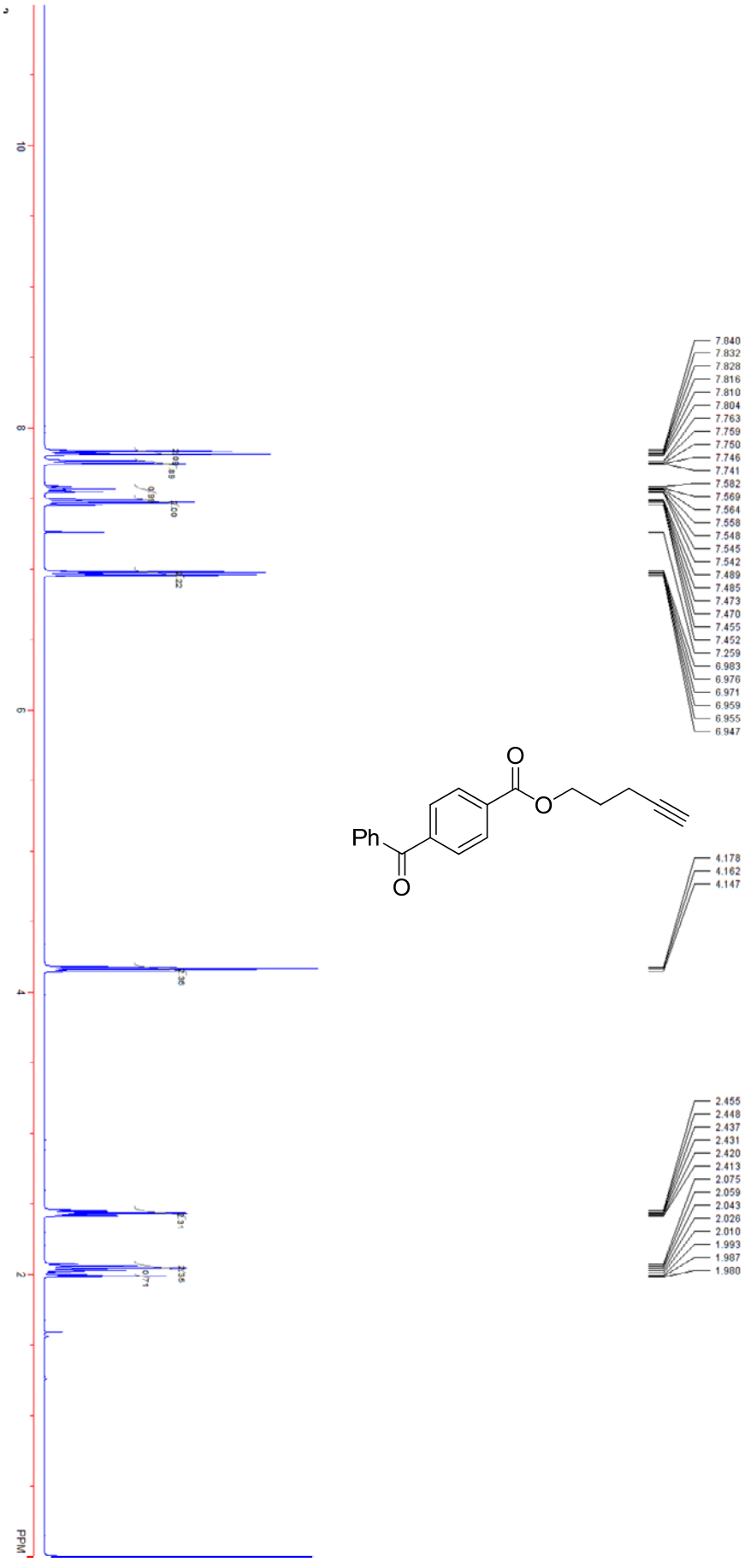
^{1}H NMR(400 MHz, $CDCl_3$) δ 6.19 (ddd, *J* = 2.0, 2.0, 2.0 Hz, 1H), 4.36 (dt, *J* = 13.2, 1.6 Hz, 1H), 4.23 (dd, *J* = 13.2, 2.0 Hz, 1H), 4.06 (dd, *J* = 9.2, 2.0 Hz, 1H), 3.96 (dd, *J* = 9.2, 5.6 Hz, 1H), 3.23-3.14 (m, 1H), 2.68-2.50 (m, 1H), 2.34-2.15 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.8, 120-100 (m), 72.7 (d, *J* = 4.7 Hz), 71.4, 69.7, 41.1, 31.7 (t, *J* = 20.5 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ -80.8 (bs, 3F), -112.7 (dt, *J* = 270.7, 23.3 Hz, 1F), -114.0 (dt, *J* = 270.7, 24.1 Hz, 1F), -121.7 (bs, 2F), -122.8 (bs, 2F), -123.6 (bs, 2F), -126.1 (bs, 2F); HRMS: m/z (APPI) calculated $[M-I]^+$: 415.0368, measured: 415.0361.



^{1}H NMR(400 MHz, $CDCl_3$) δ 6.39 (t, *J* = 14.8 Hz, 1H), 1.57-1.46 (m, 1H), 0.89-0.79 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 129.9, 125.6 (t, *J* = 3.5 Hz),120-100 (m), 17.9, 11.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ -80.8 (t, *J* = 9.4 Hz, 3F), -104.5 (t, *J* = 12.4 Hz, 2F), -121.7 (m, 2F), -122.8 (m, 2F), -123.2 (m, 2F), -126.1 (m, 2F); LRMS: m/z (EI) 385 (M-I, 100), 365, 196, 166, 146, 127, 115, 97, 69.
Z product: ^{19}F NMR (376 MHz, $CDCl_3$) δ -80.8 (t, *J* = 8.3 Hz, 3F), -107.2 (t, *J* = 12.4 Hz, 2F), -121.6 (m, 2F), -122.8 (m, 4F), -126.1 (m, 2F); LRMS: m/z (EI) 385 (M-I, 100), 365, 196, 166, 146, 127, 115, 97, 69.



^{1}H NMR(400 MHz, $CDCl_3$) δ 5.81-5.70 (m, 1H), 5.54-5.42 (m, 1H), 3.21 (td, *J* = 7.2, 1.6 Hz, 2H), 2.70 (tdd, *J* = 7.2, 6.8, 2.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 206.7 (t, *J* = 7.8 Hz), 120-100 (m), 97.7, 85.7 (t, *J* = 28.2 Hz), 31.5, 2.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ -80.8 (m, 3F), -108.2 (m, 2F), -121.6 (m, 2F), -122.9 (m, 2F), -123.2 (m, 2F), -126.1 (m, 2F); LRMS: m/z (EI) 385 (M-I, 100), 365, 345, 295, 196, 166, 155, 146, 127, 115, 97, 69.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7.564
7.558
7.548
7.545
7.542
7.489
7.485
7.473
7.470
7.455
7.452
7.259
6.983
6.976
6.971
6.959
6.955
6.947
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2.437
2.431
2.420
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2.043
2.026
2.010
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1.987
1.980
Ph
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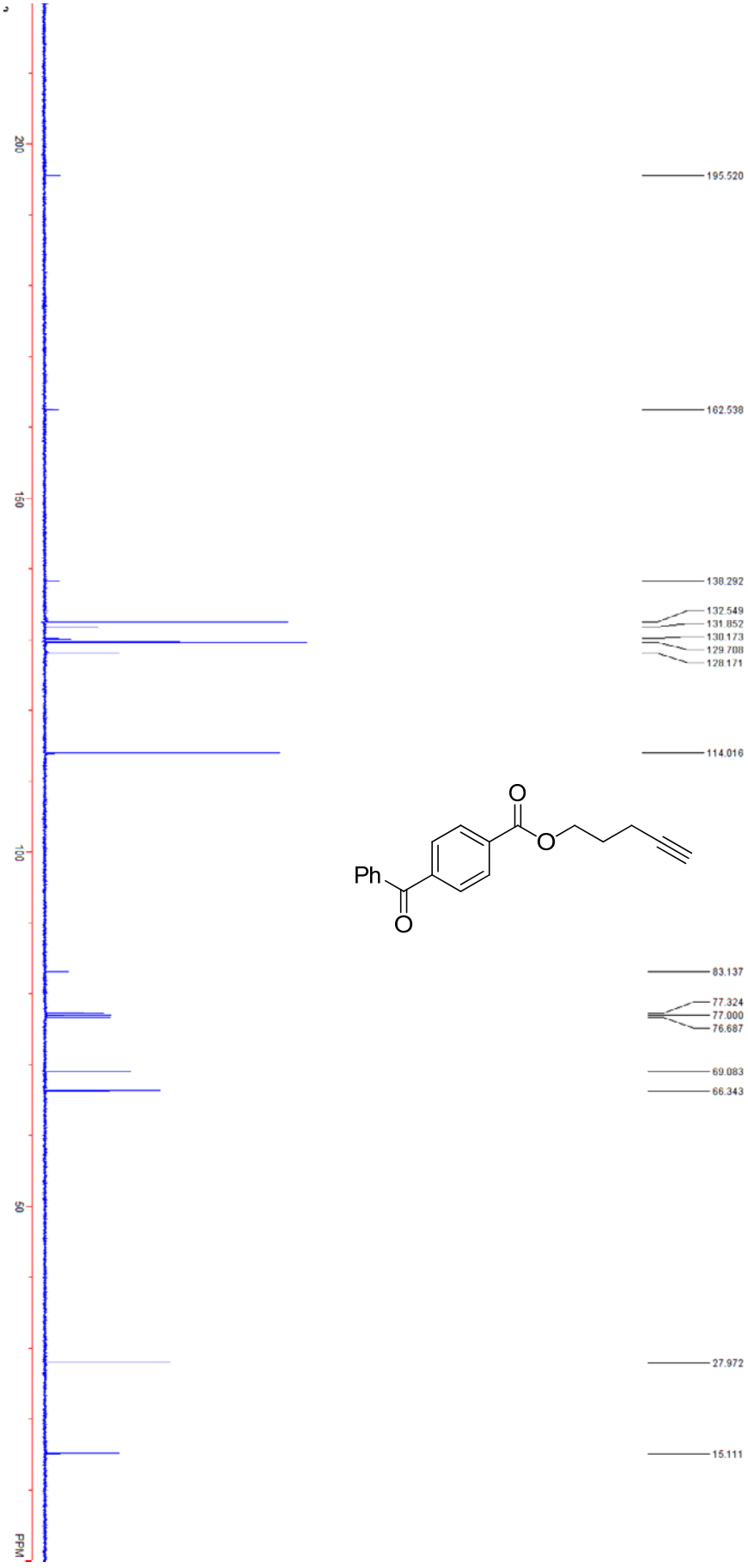
O
O
PPM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128.171
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69.083
66.343
27.972
15.111
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150
100
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Ph
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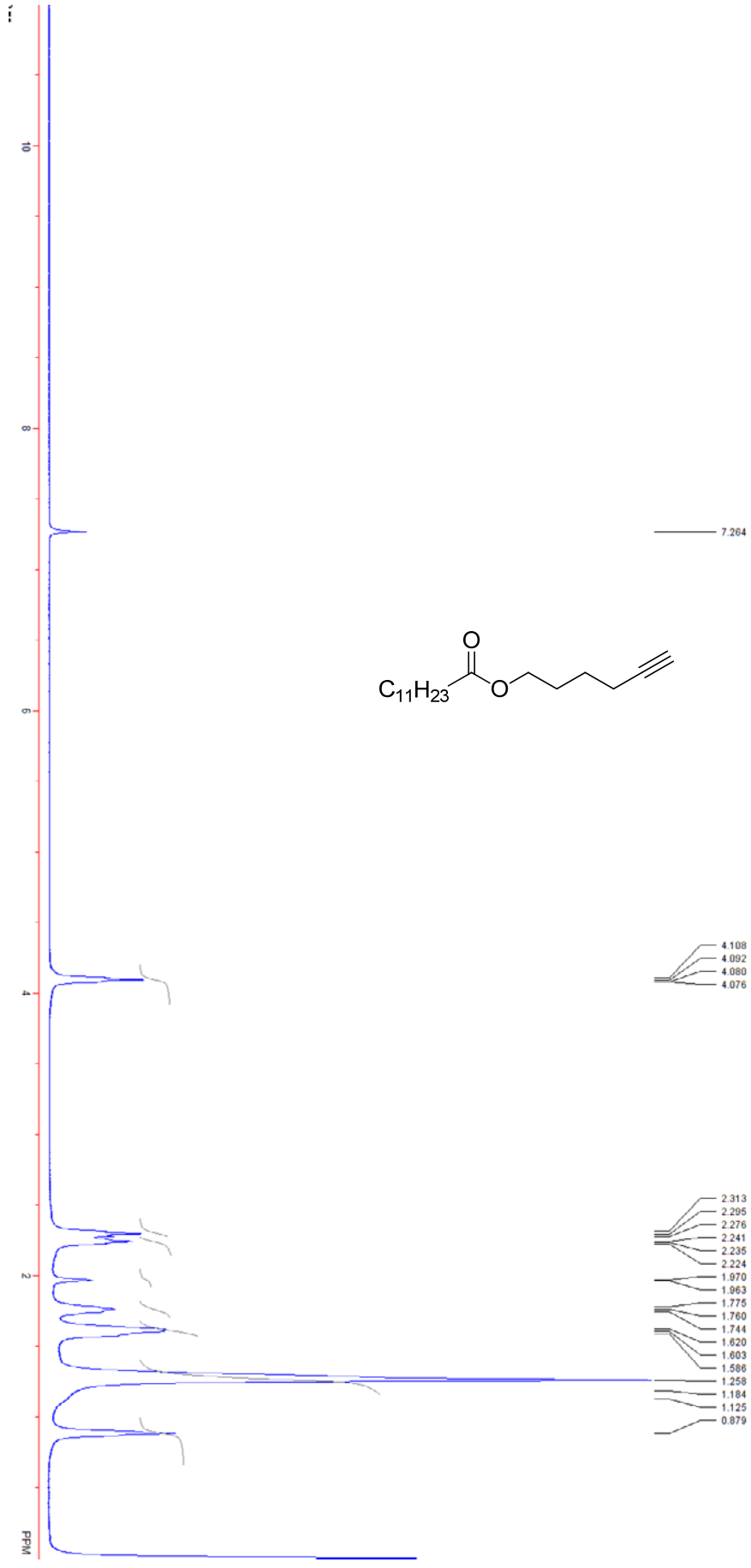
O
O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2
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4.080
4.076
2.313
2.295
2.276
2.241
2.235
2.224
1.970
1.963
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1.620
1.603
1.586
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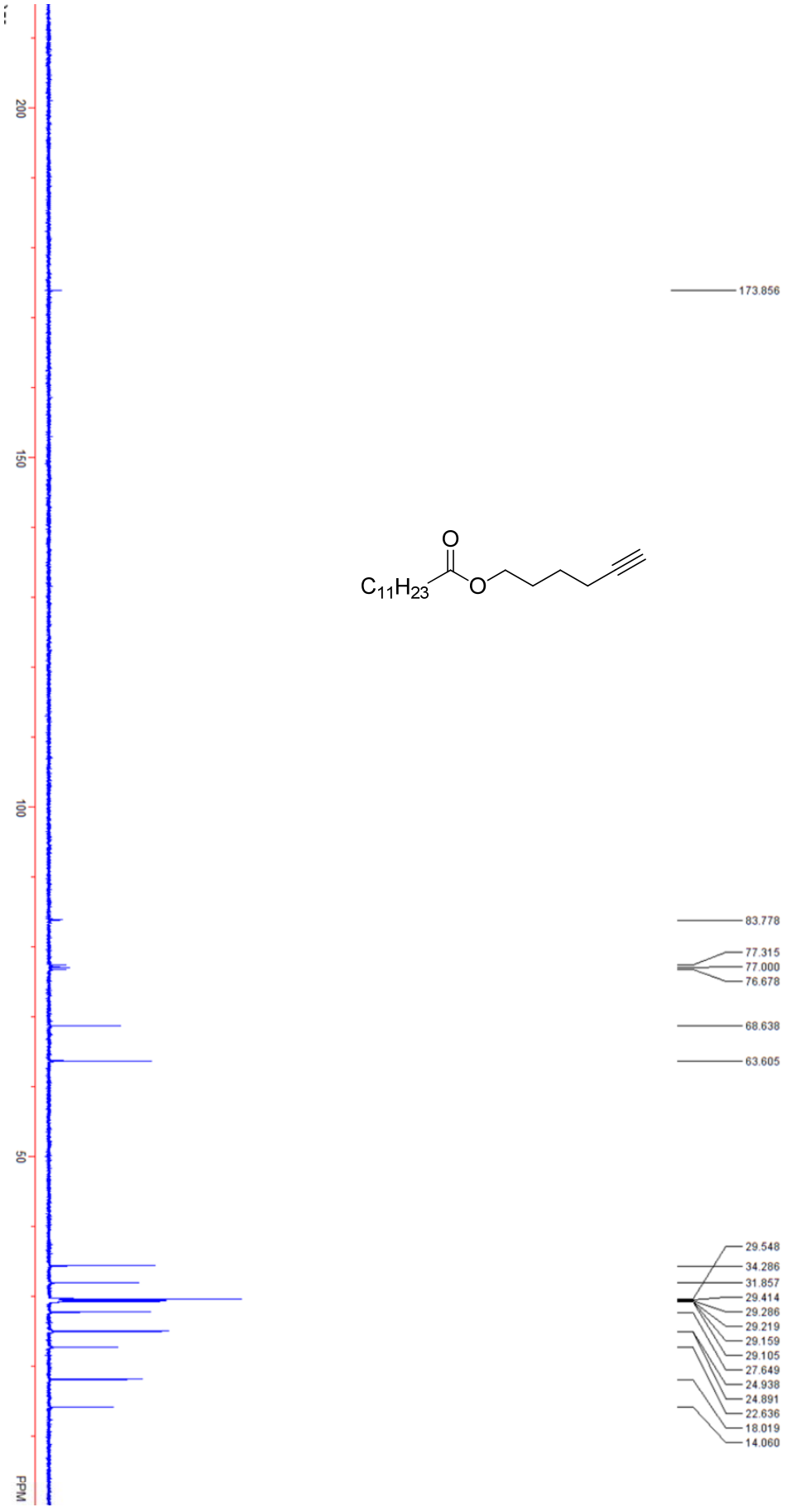
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29.105
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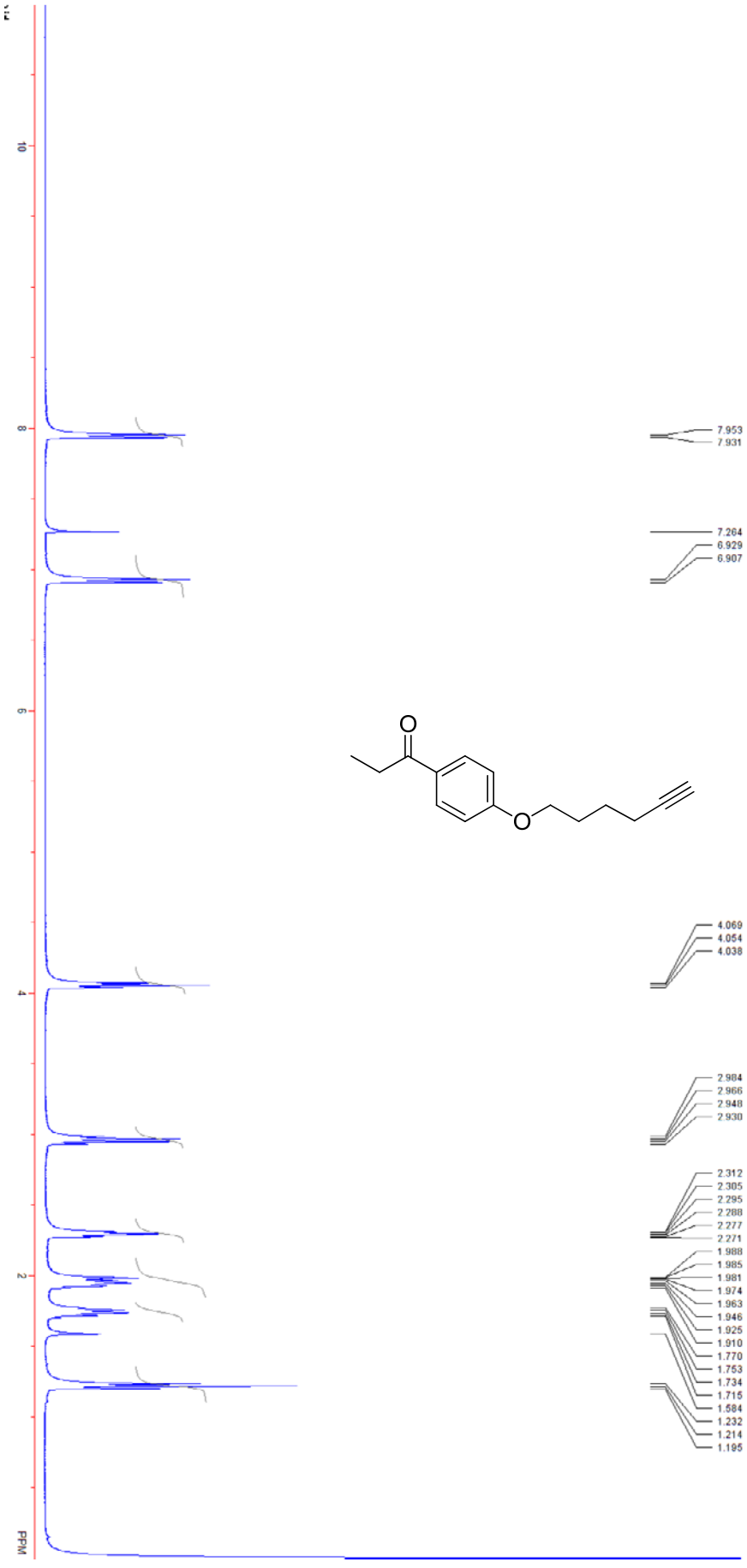
18.019
14.060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6.907
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4.038
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2.930
2.312
2.305
2.295
2.288
2.277
2.271
1.988
1.985
1.981
1.974
1.963
1.946
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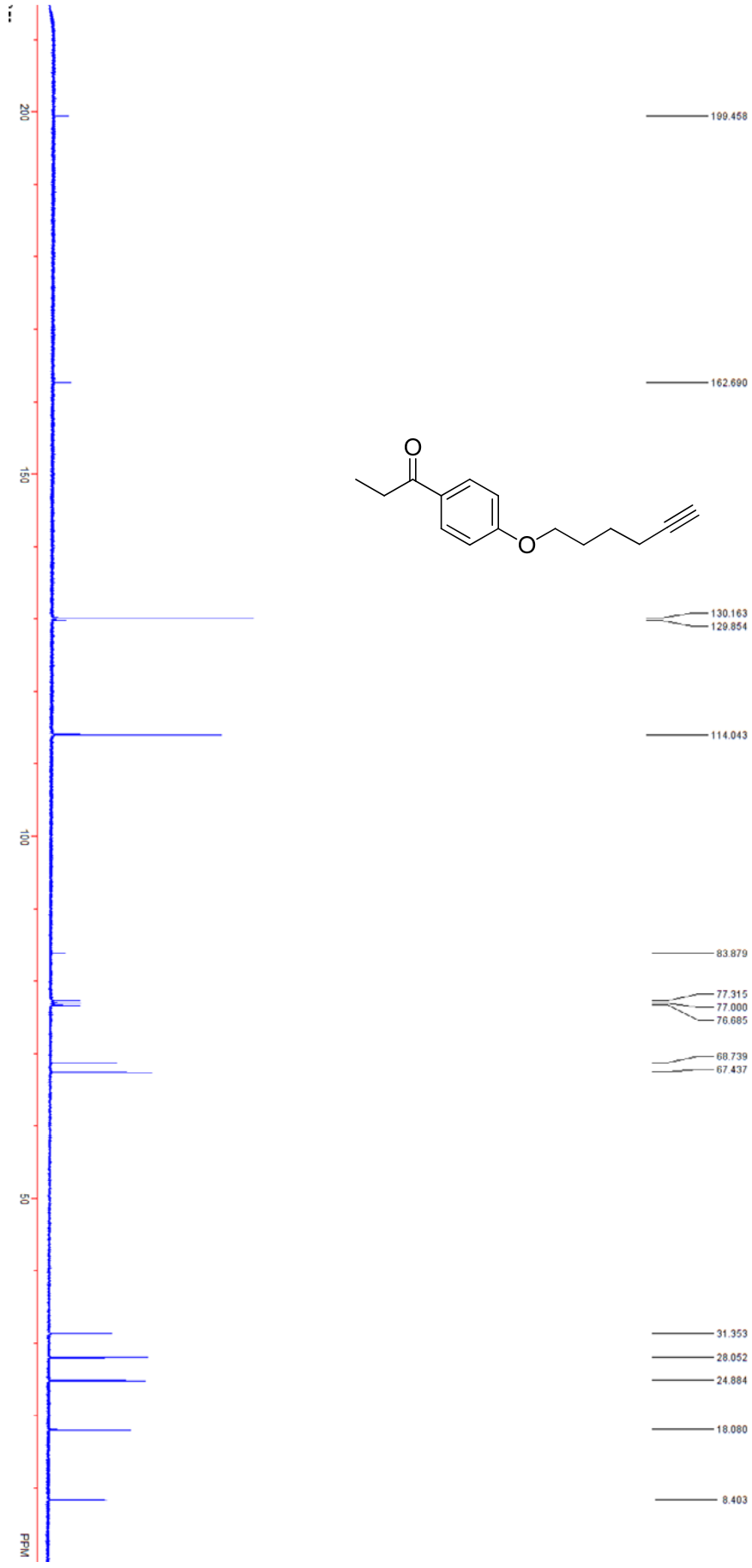
O
PPM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28.052
24.884
18.080
8.403
PPM


10
8
6
4
2
PPM
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7.967
7.962
7.955
7.951
7.945
7.940
7.920
7.406
7.402
7.395
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7.385
7.374
7.299
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O
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4.412
4.407
4.397
2.395
2.388
2.377
2.370
2.361
2.353
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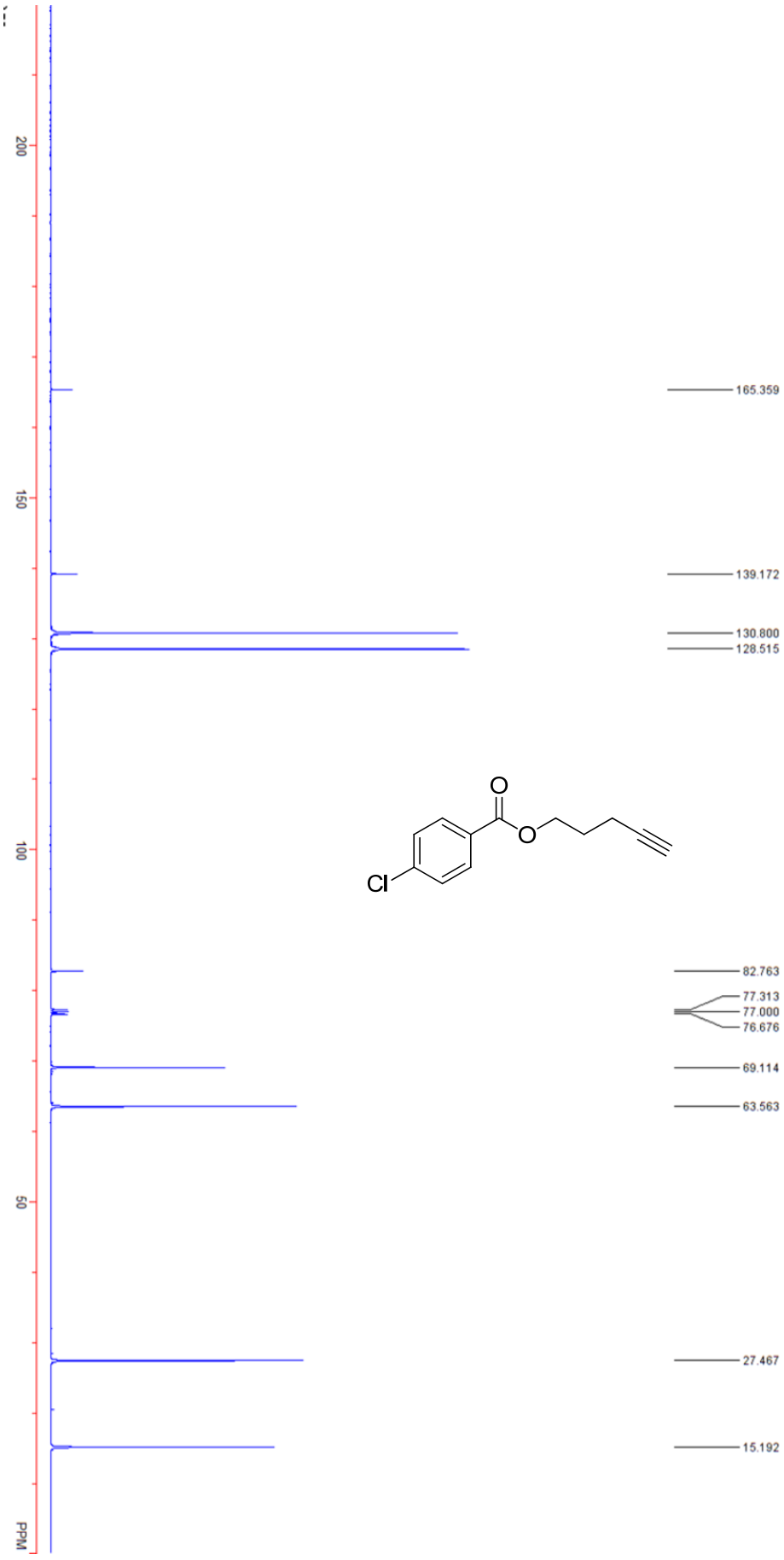
1.976
1.966
1.958
1.948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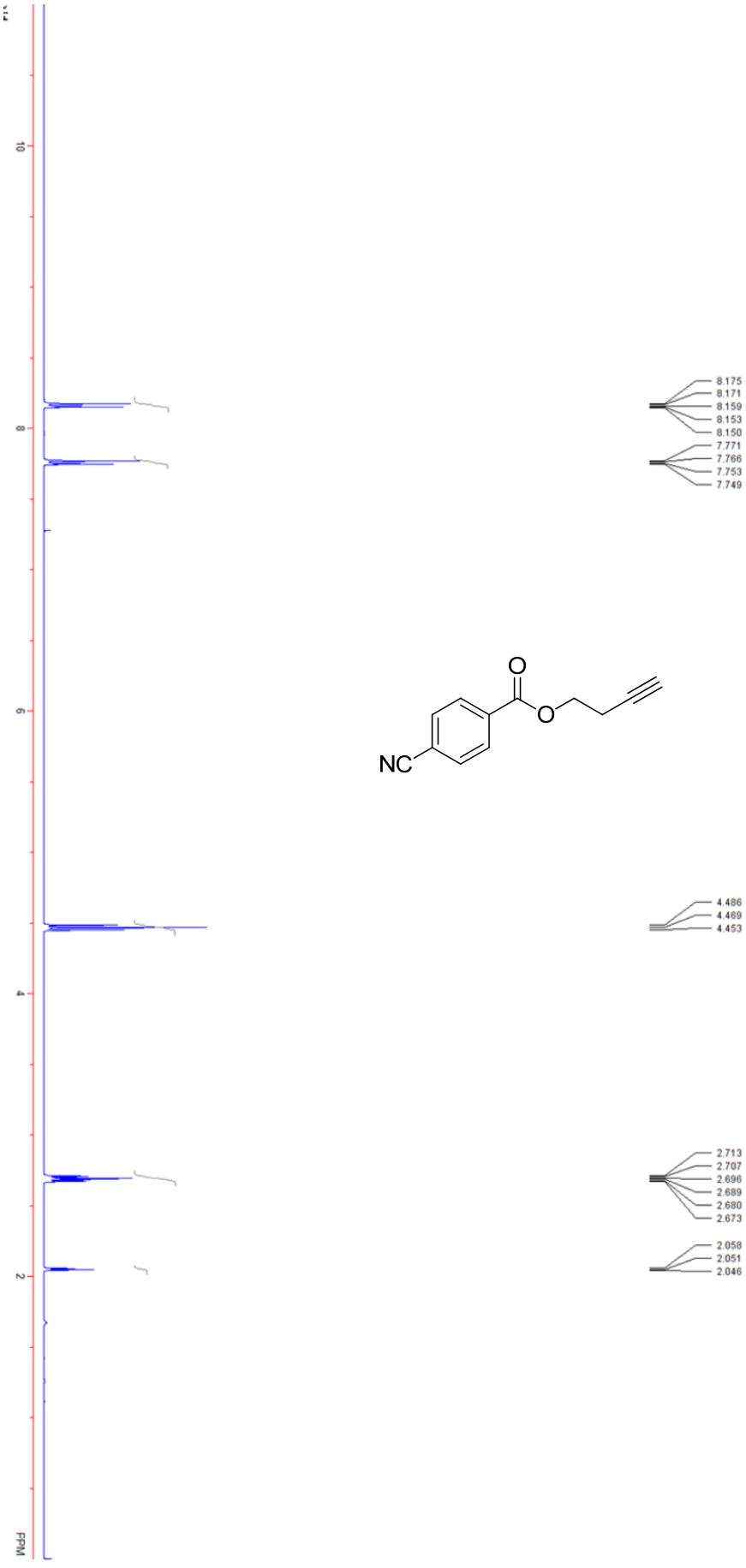
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2.689
2.680
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2.051
2.046
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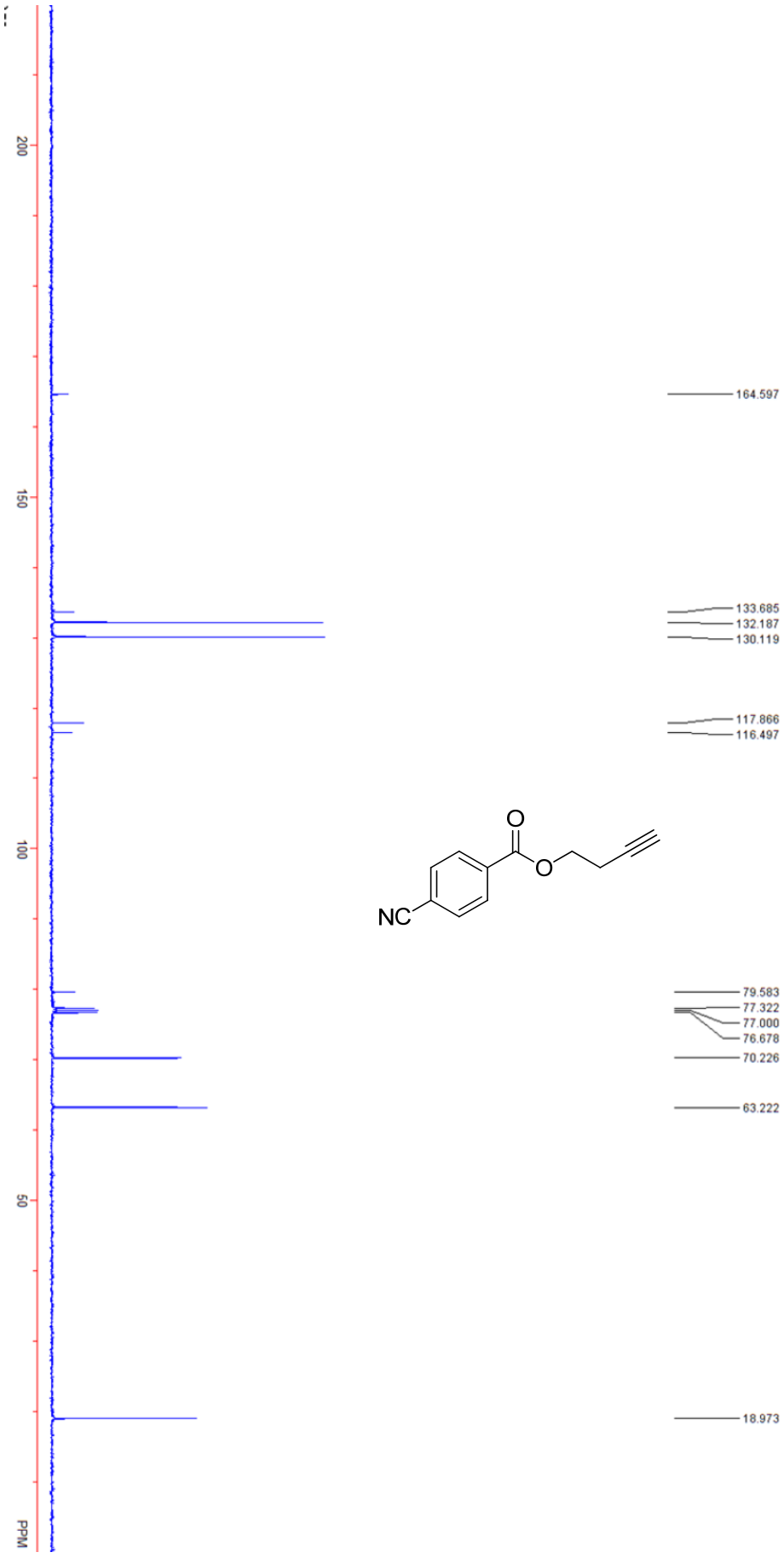
8
6
4
2
PPM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70.226
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18.973
O
O
NC


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8
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PPM
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O
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1.972
1.966
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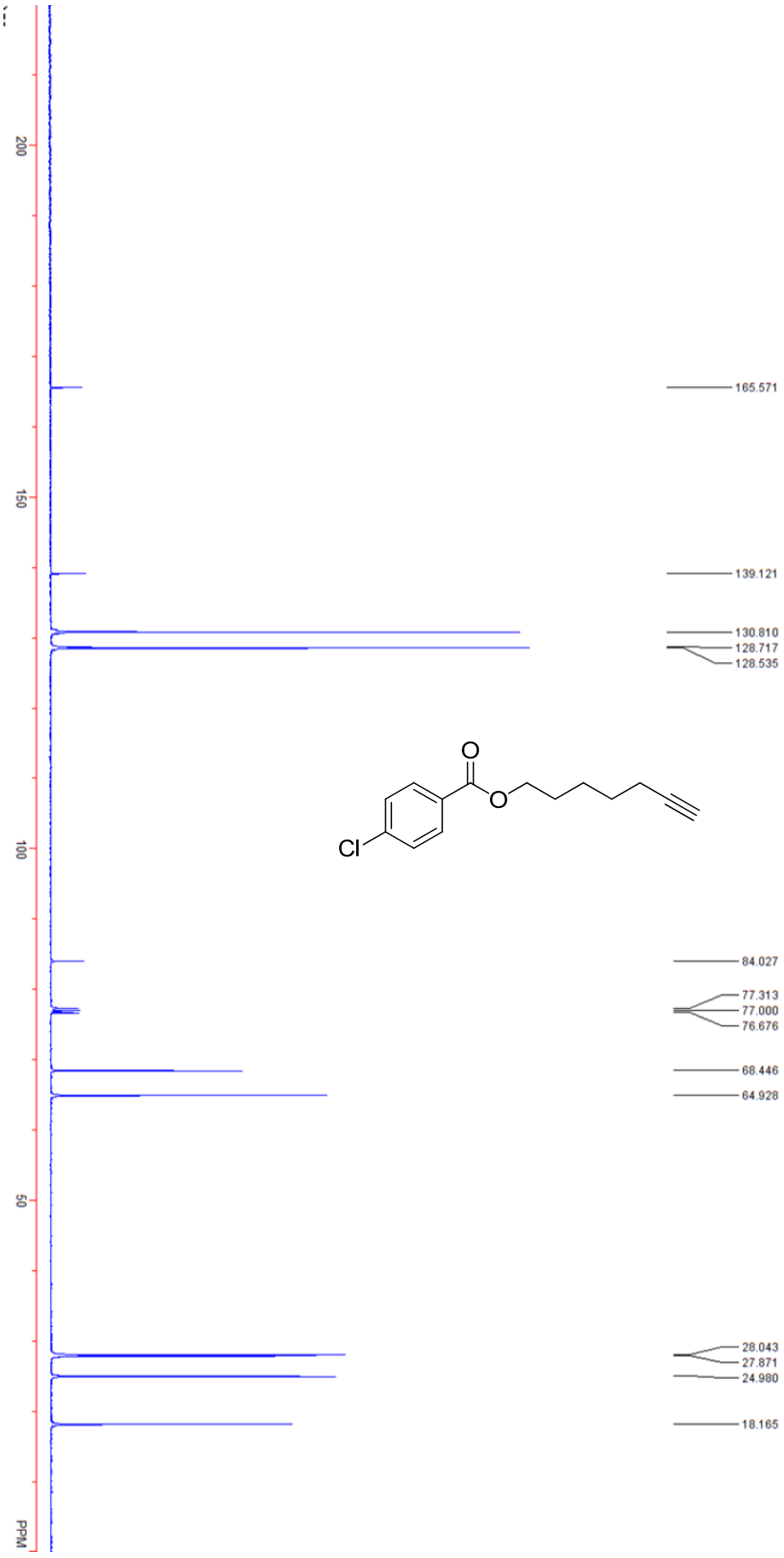
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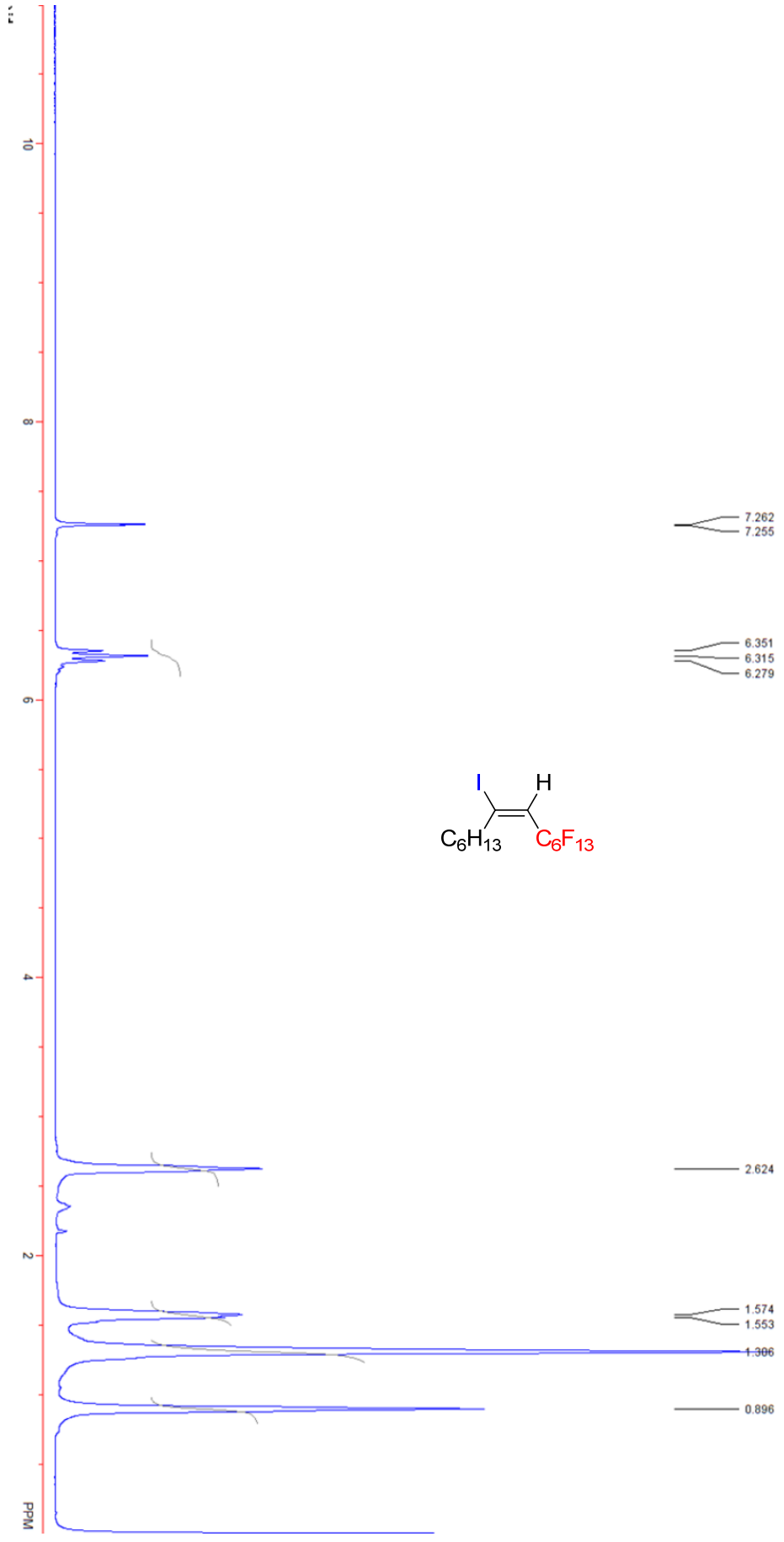
Cl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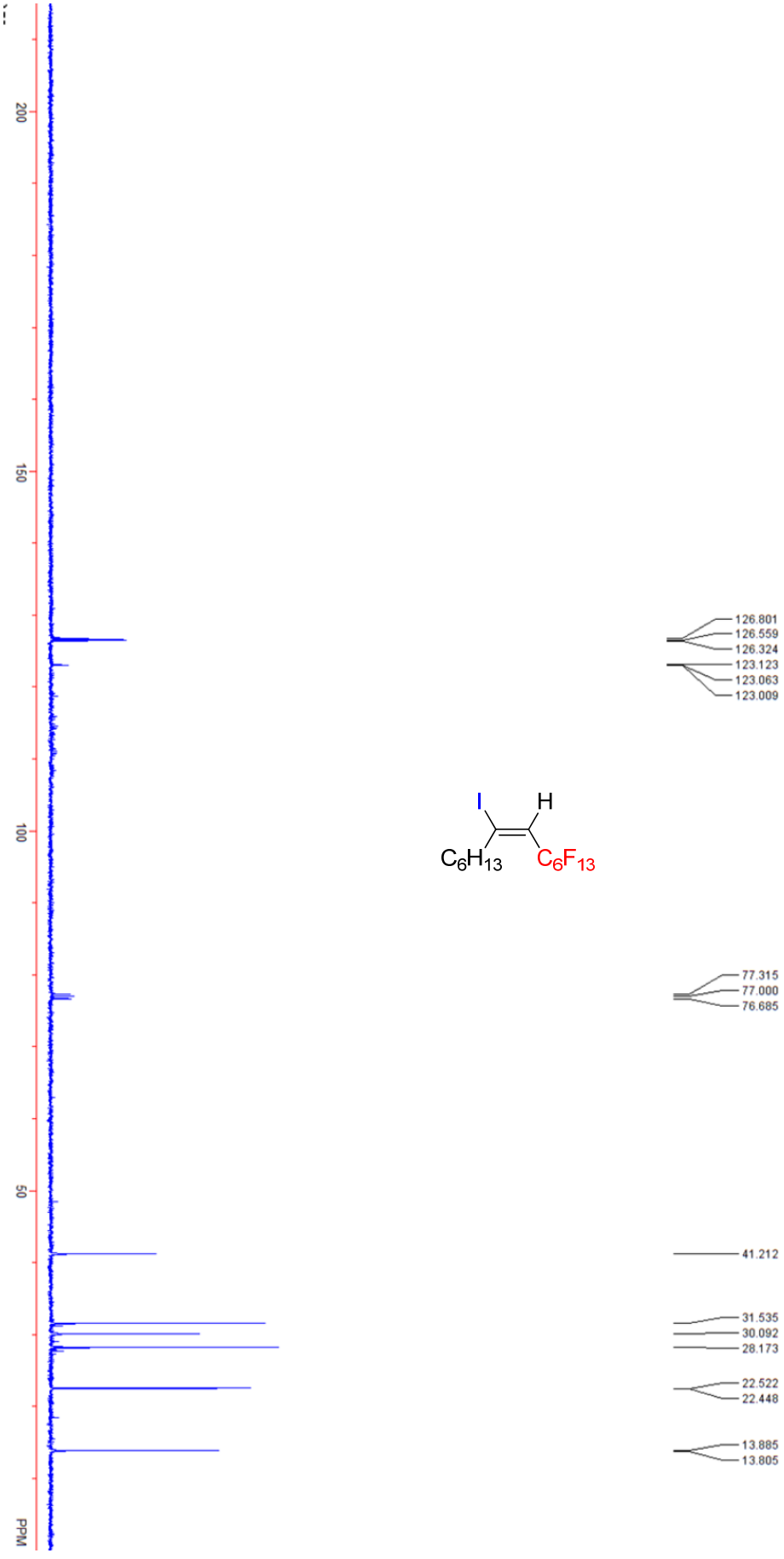
0.896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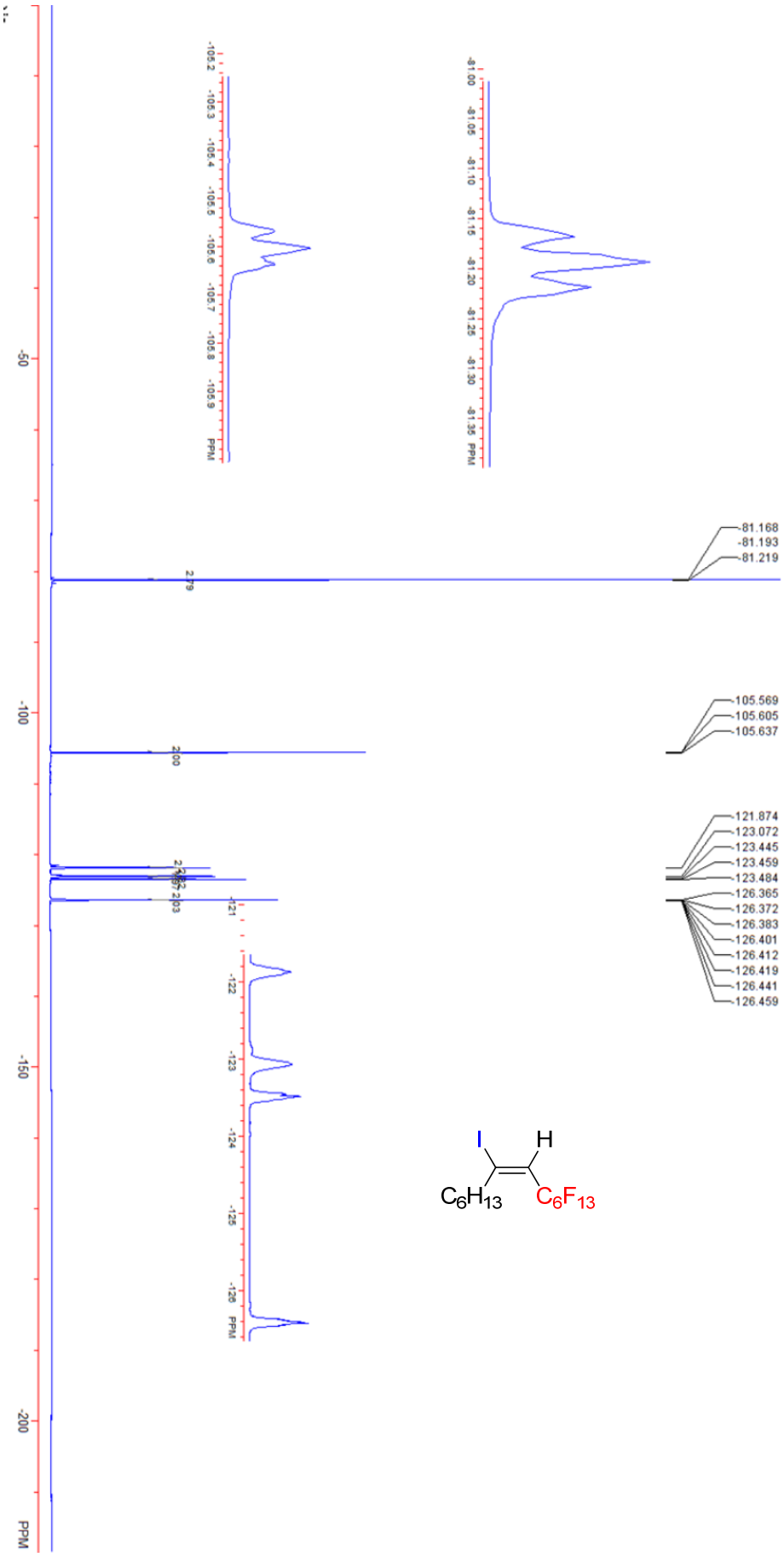
13.805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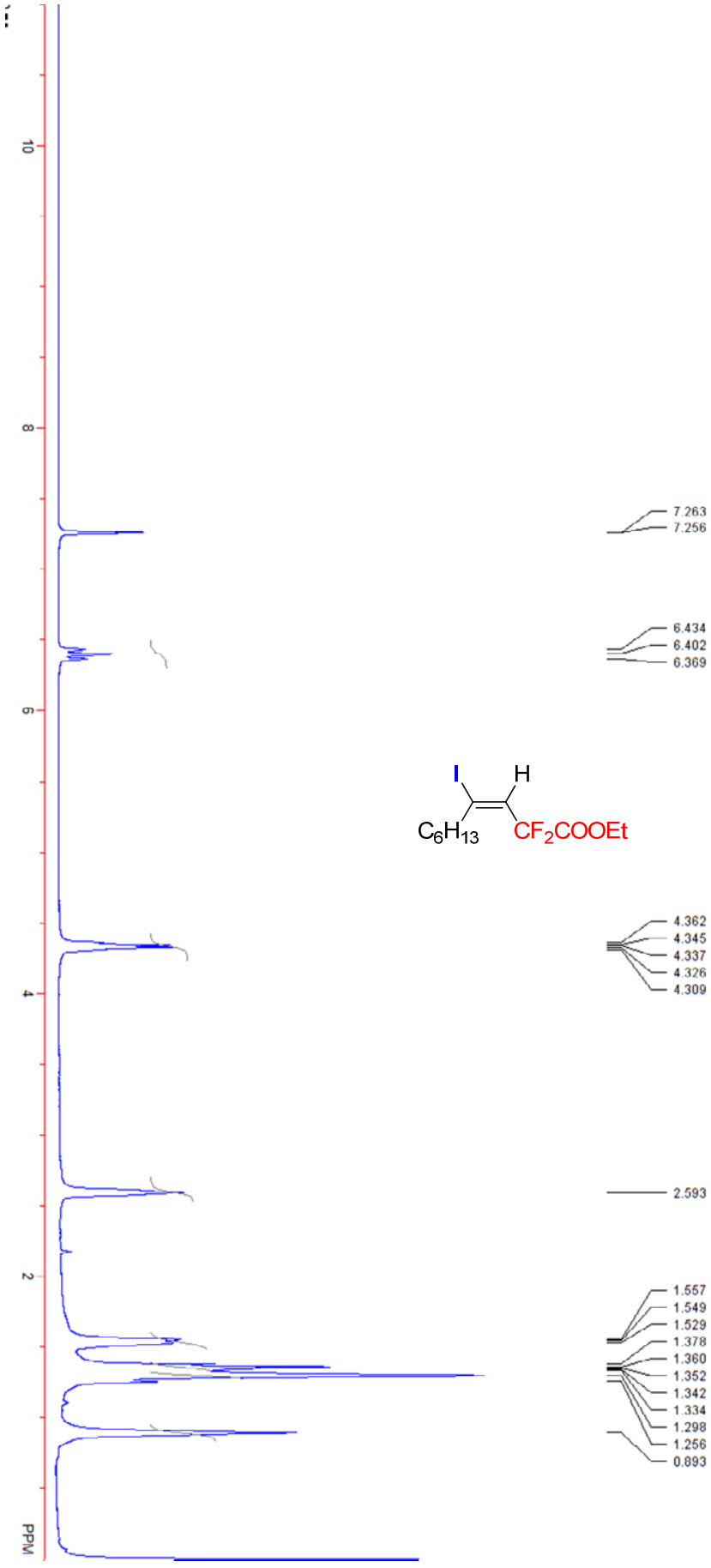
PPM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1.529
1.378
1.360
1.352
1.342
1.334
1.298
1.256
0.893


200
150
100
50
PPM
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162.851
131.438
131.169
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119.647
119.573
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77.000
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63.297
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29.817
28.011
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13.986
13.858
I
H
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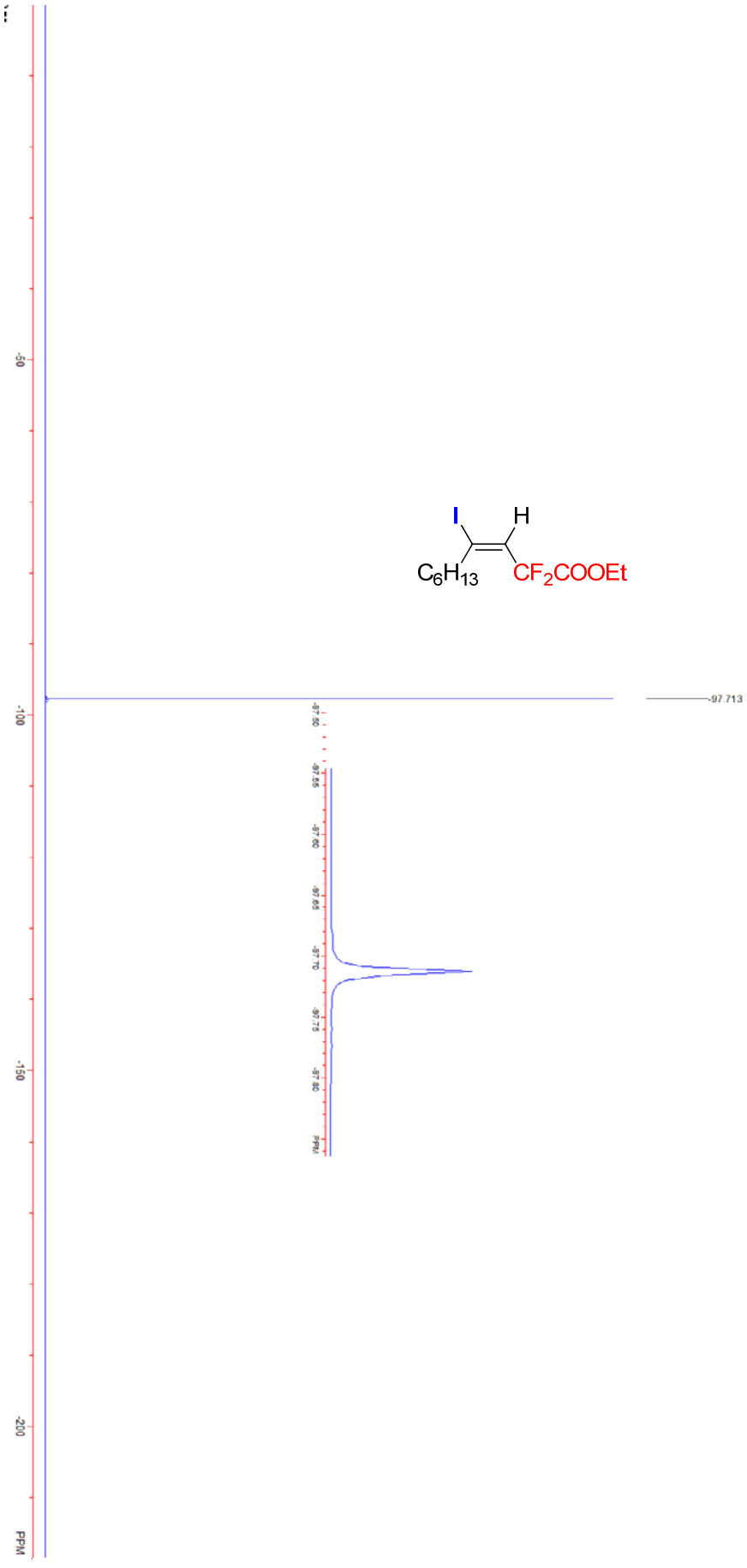
CF2COOEt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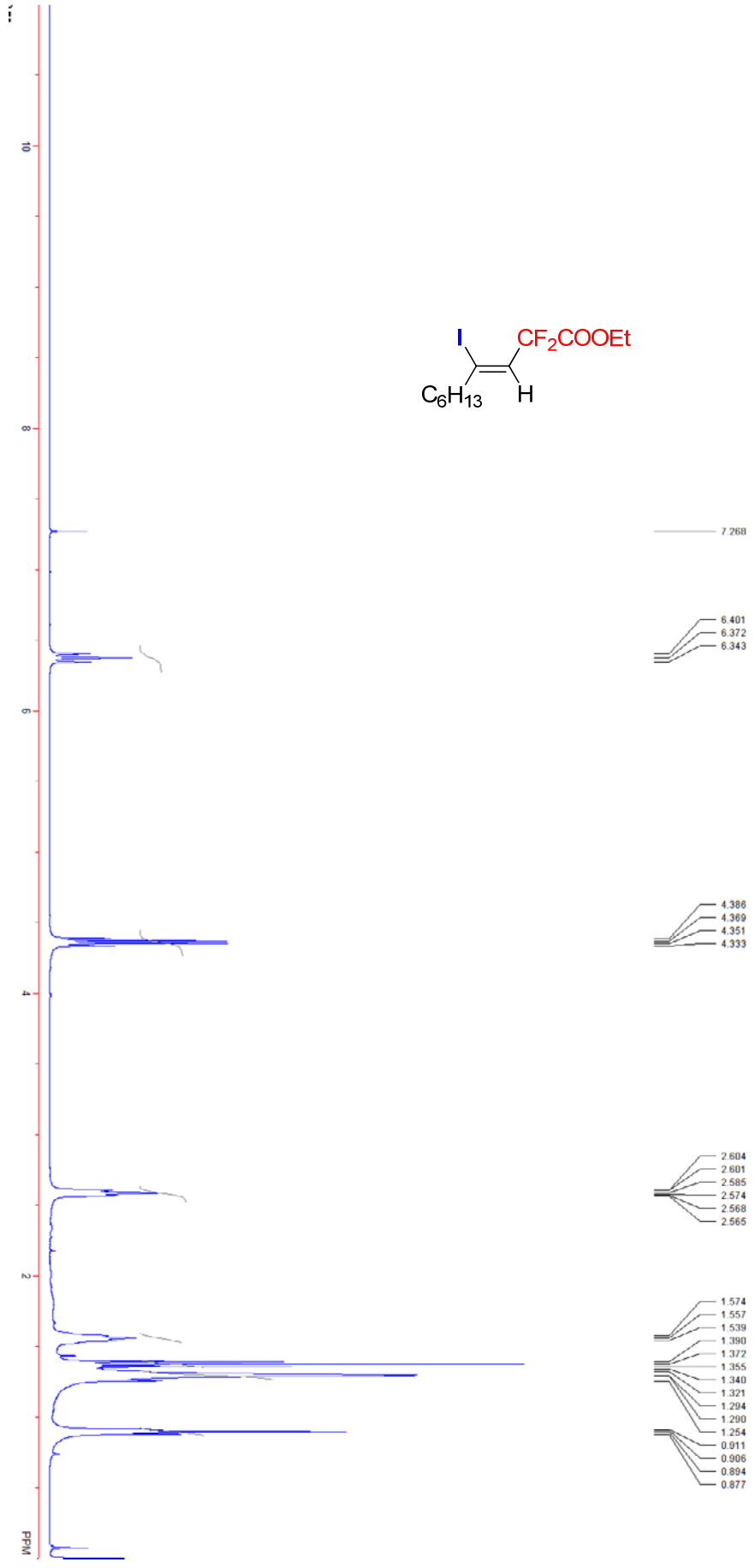
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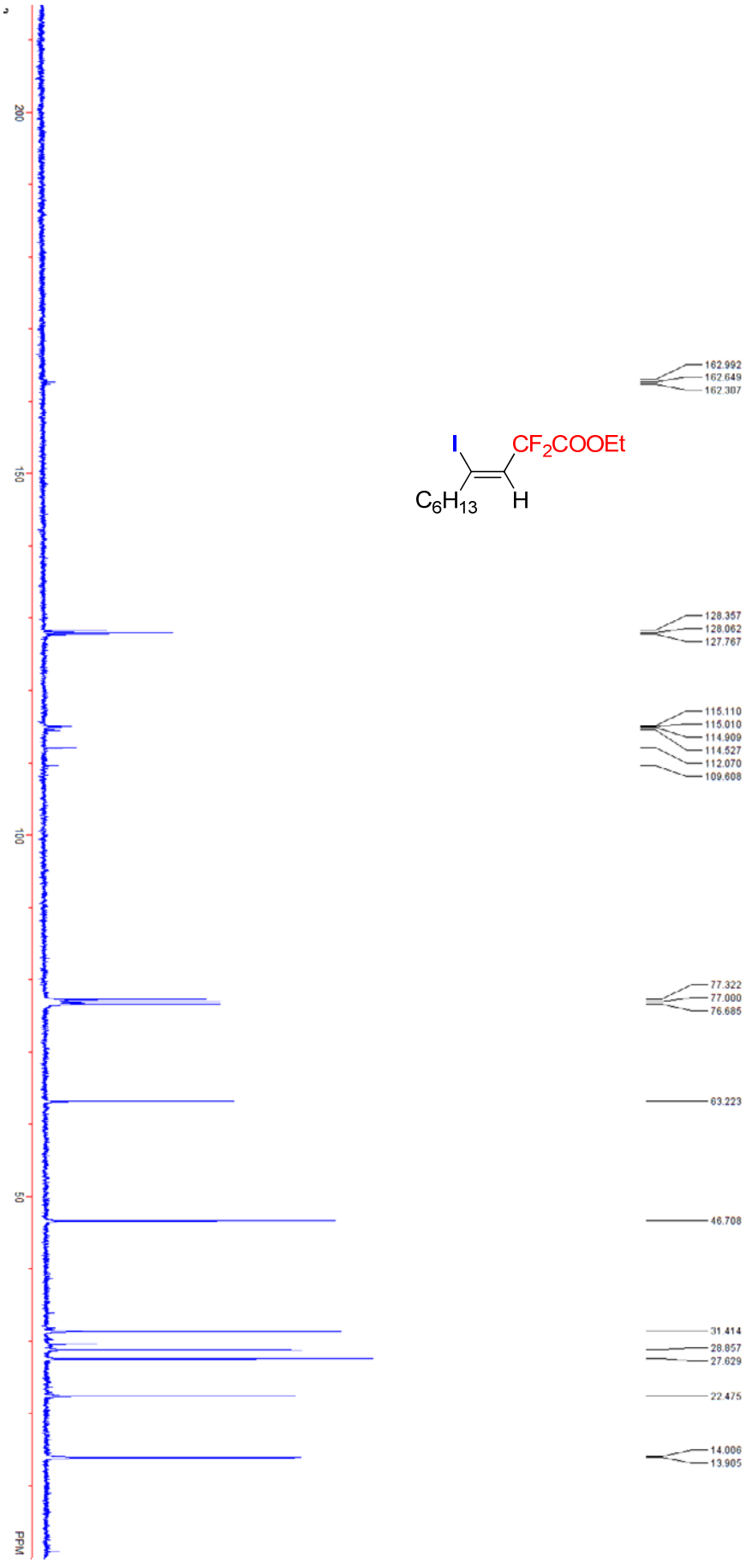
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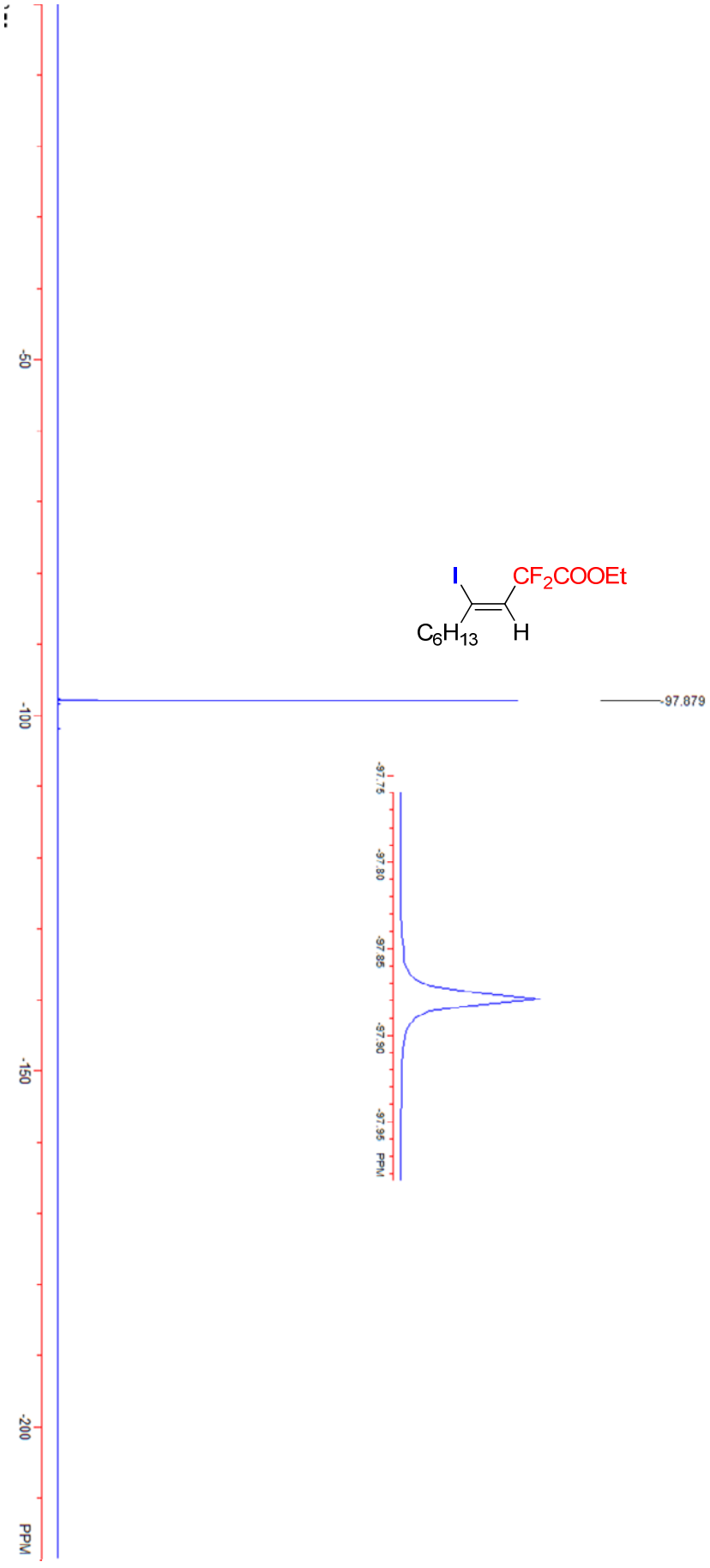
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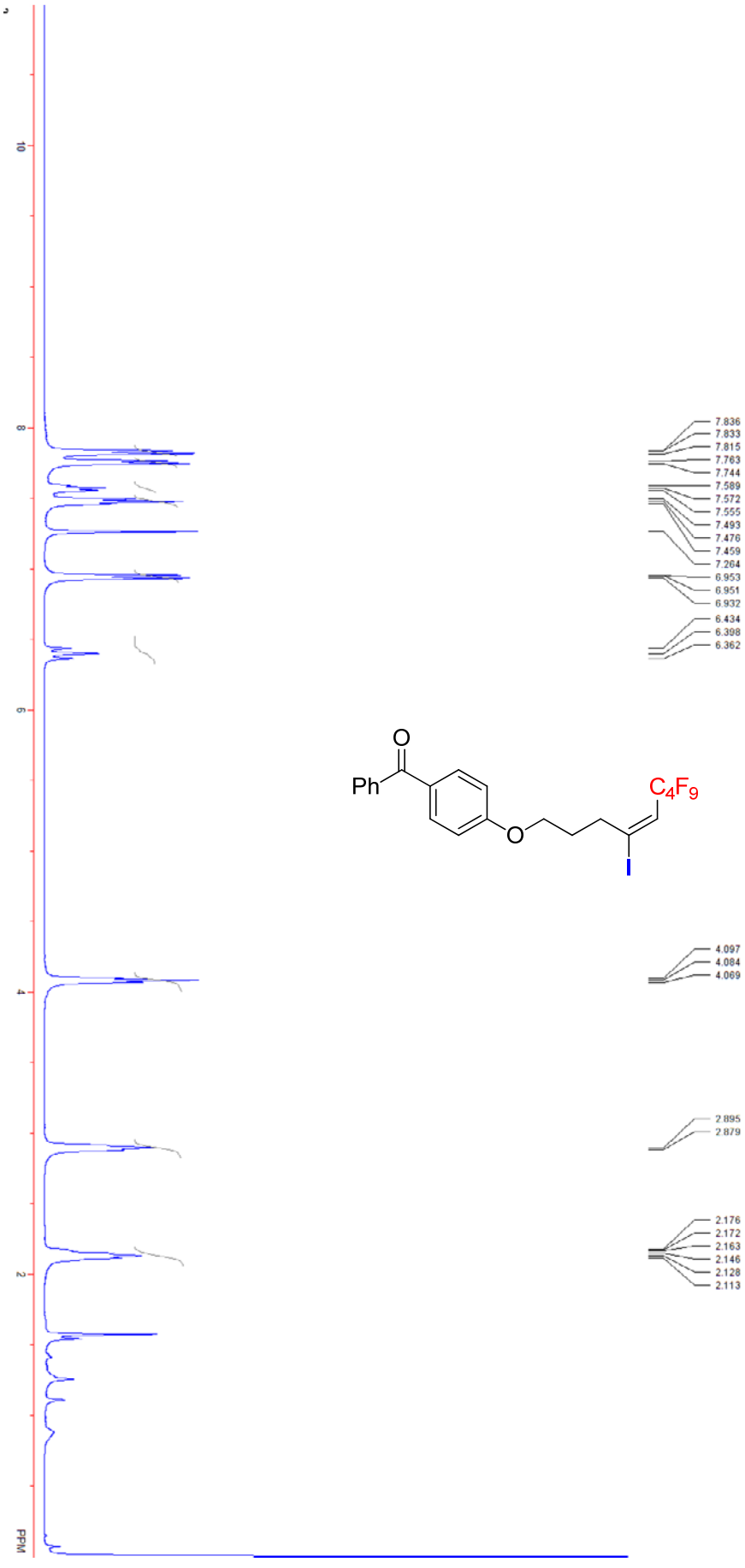
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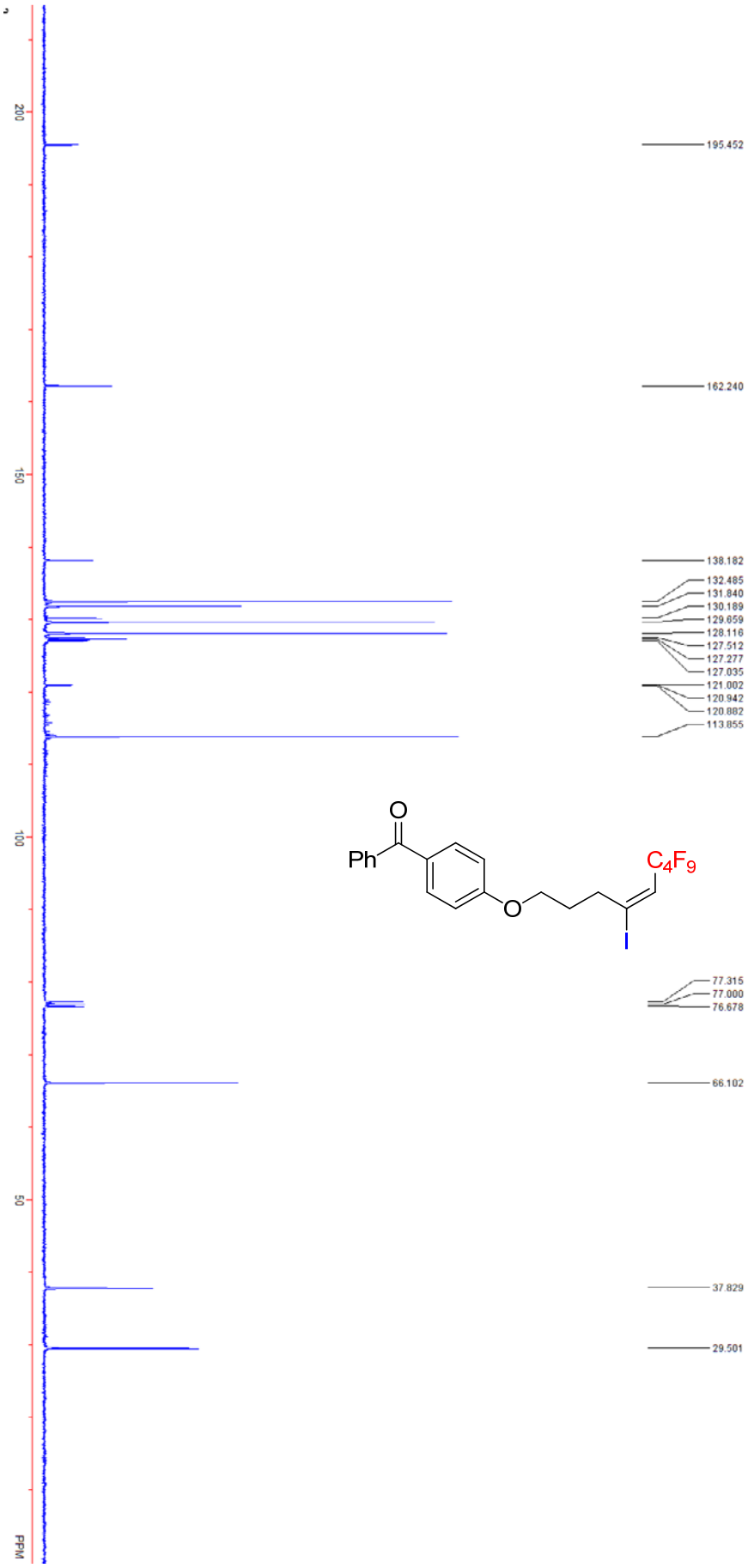
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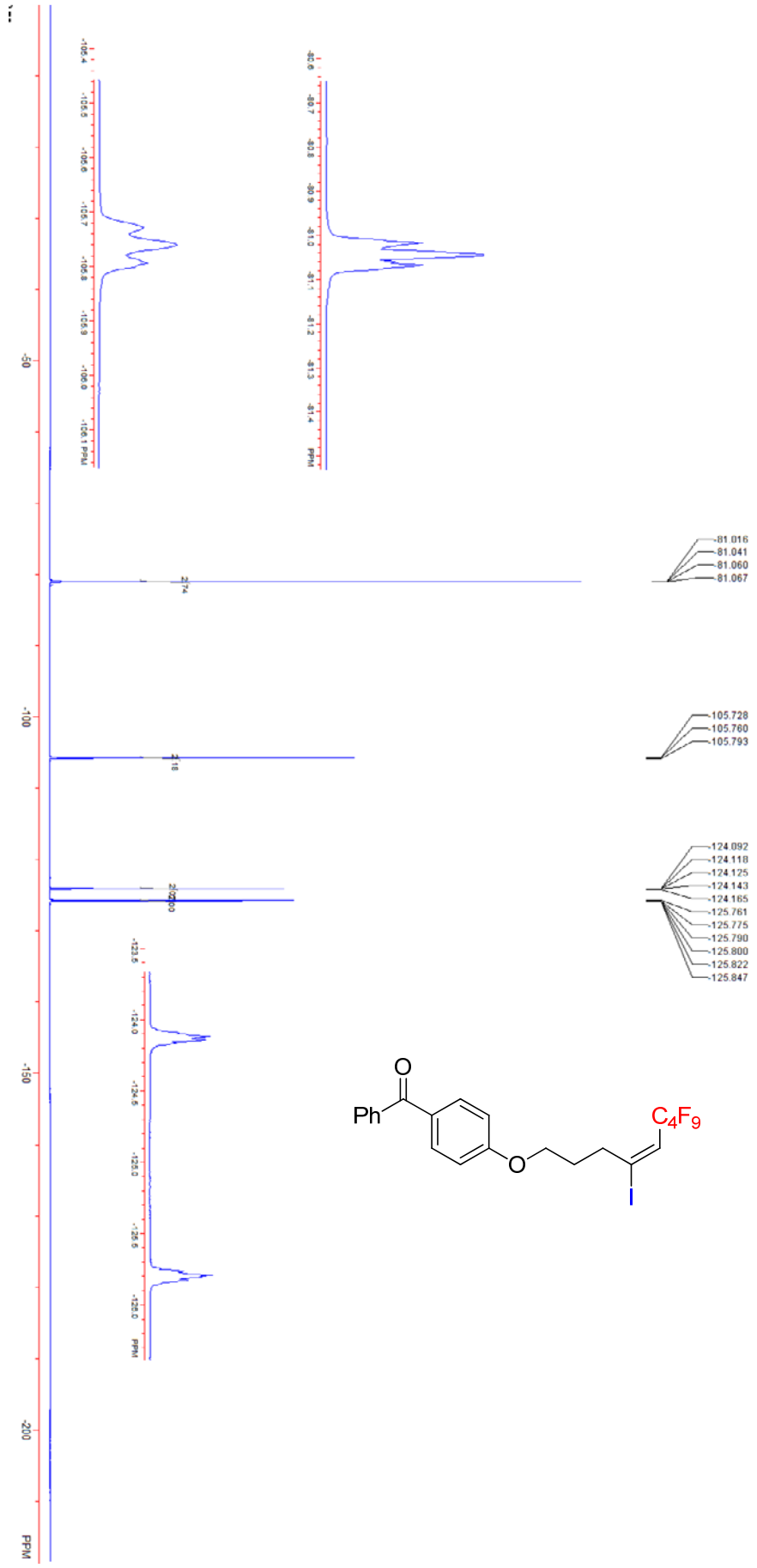
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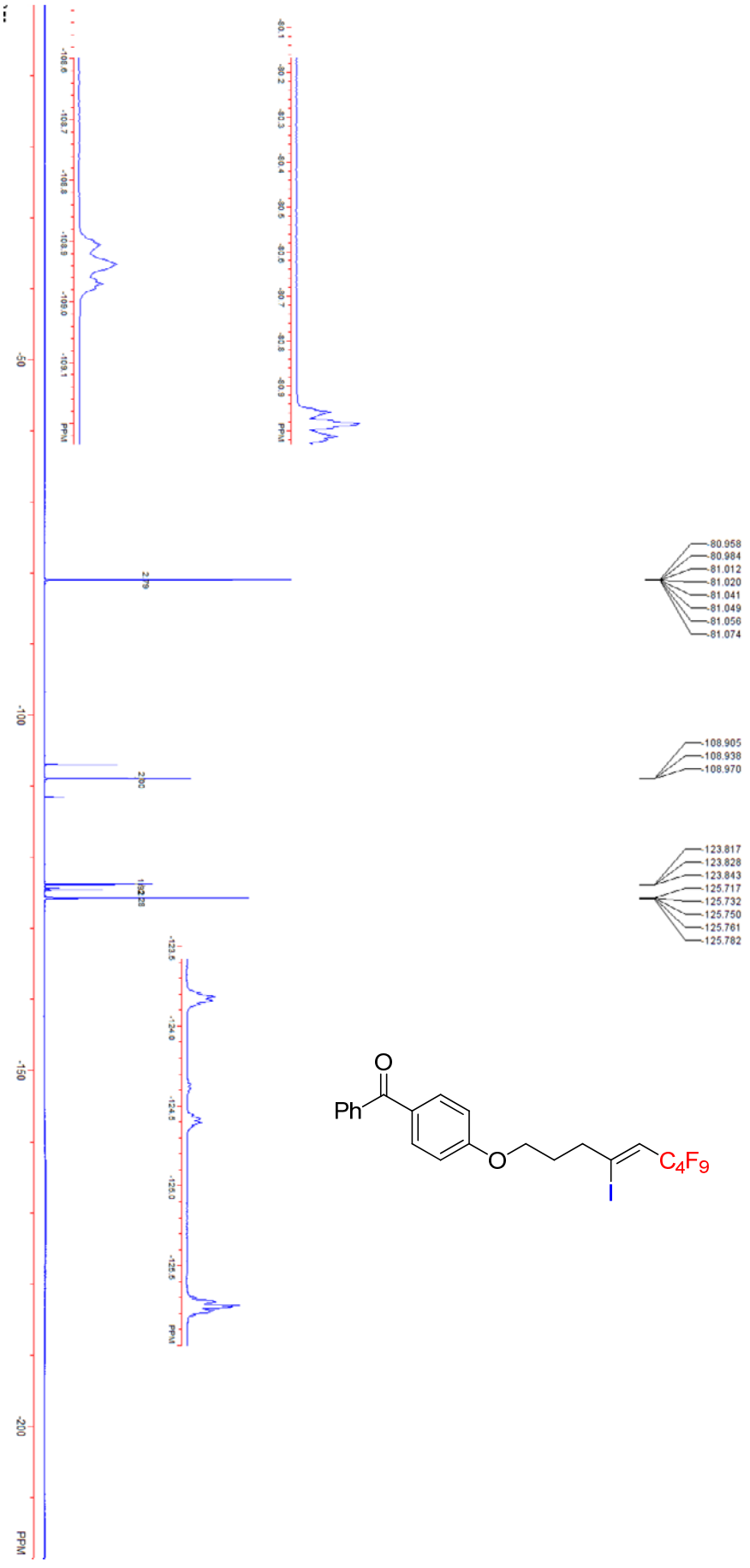
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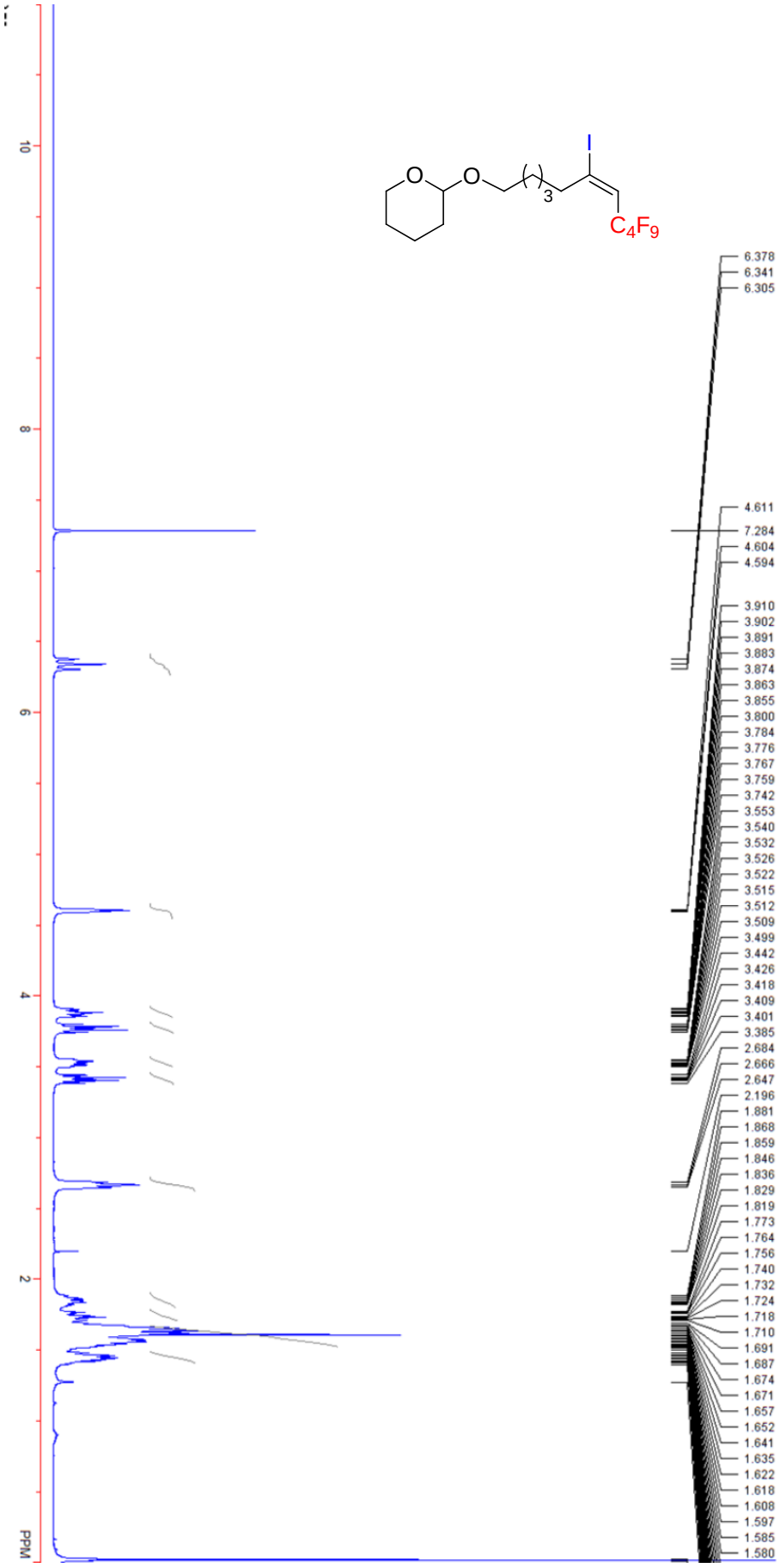
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3.512
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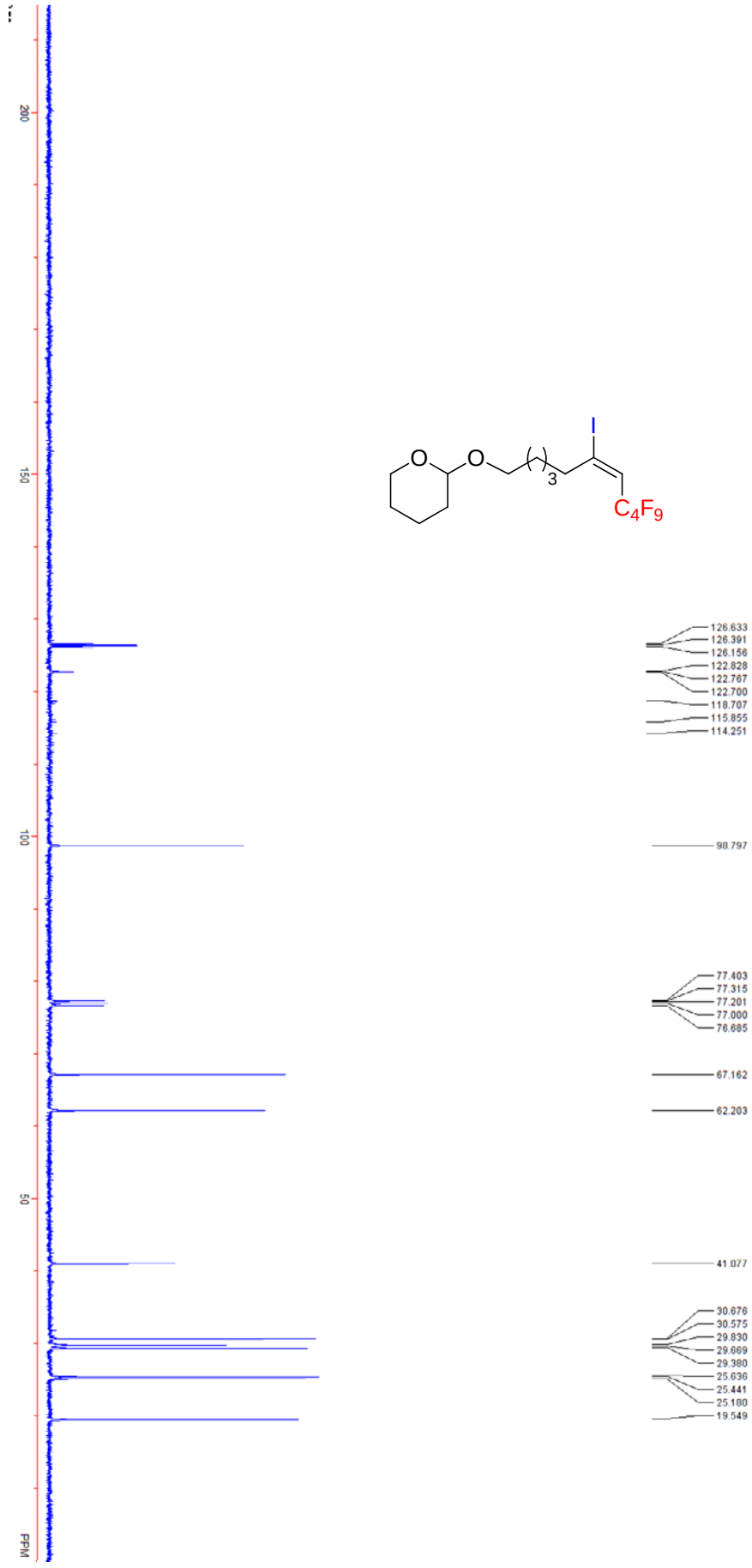
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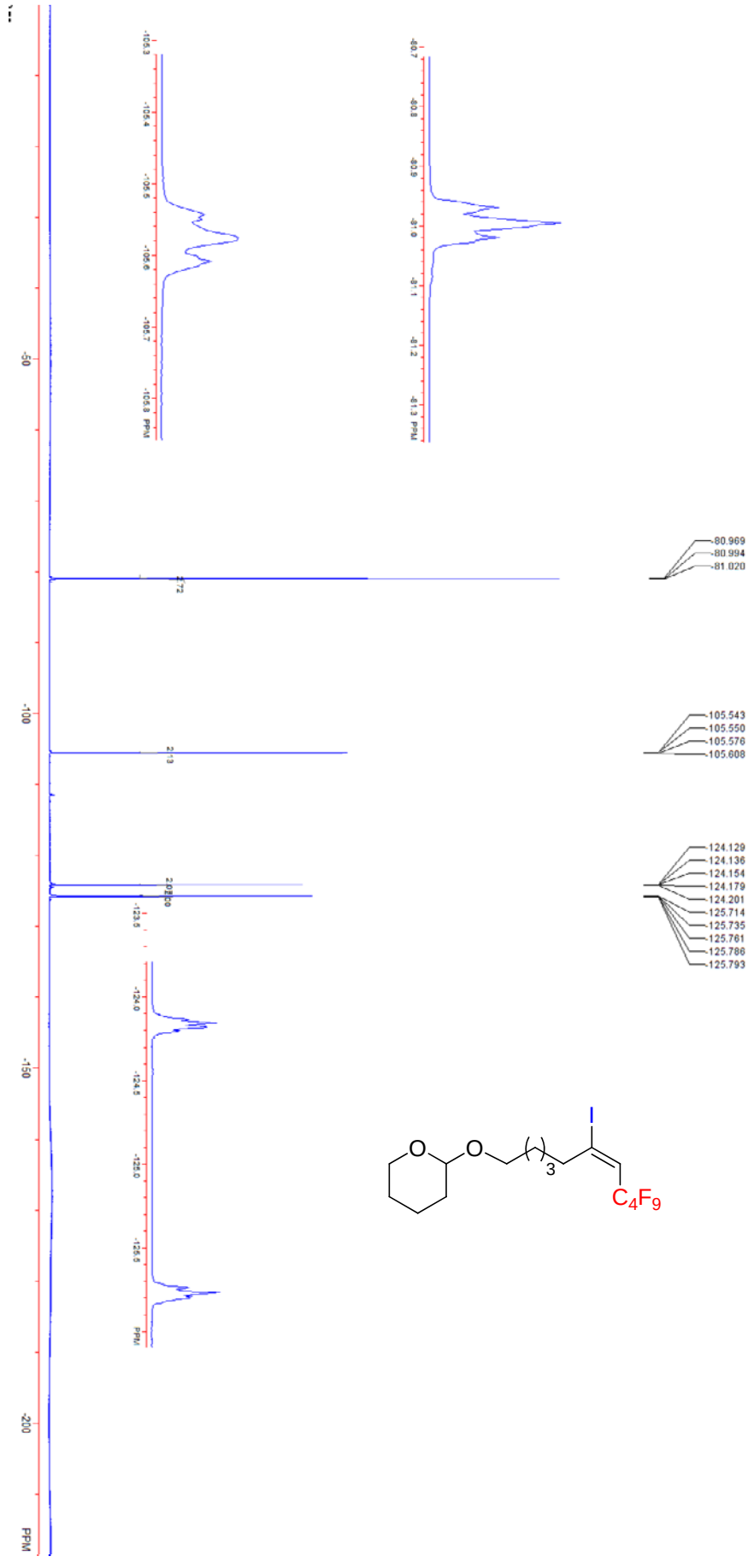
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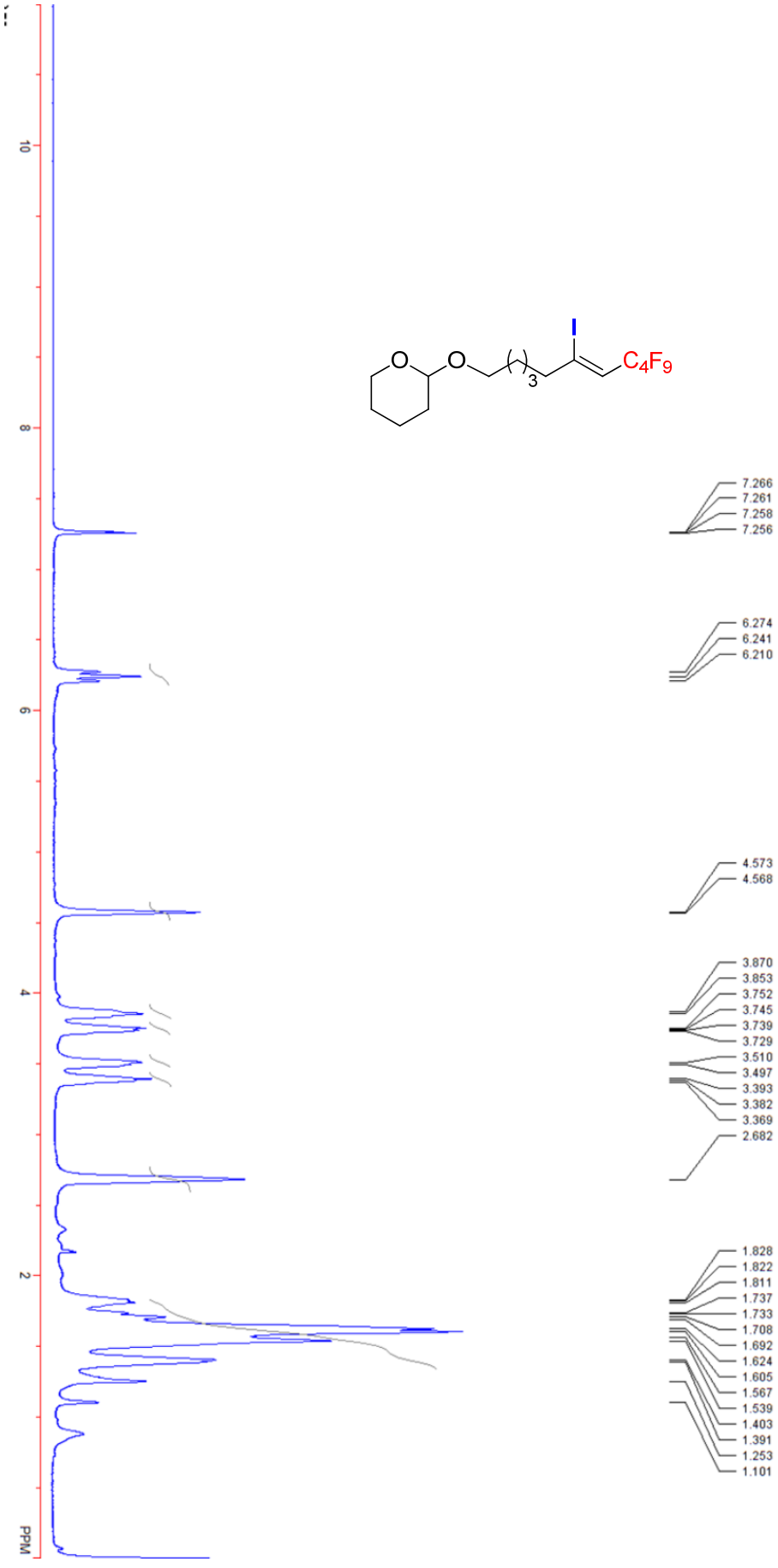
I
C4F9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4
2
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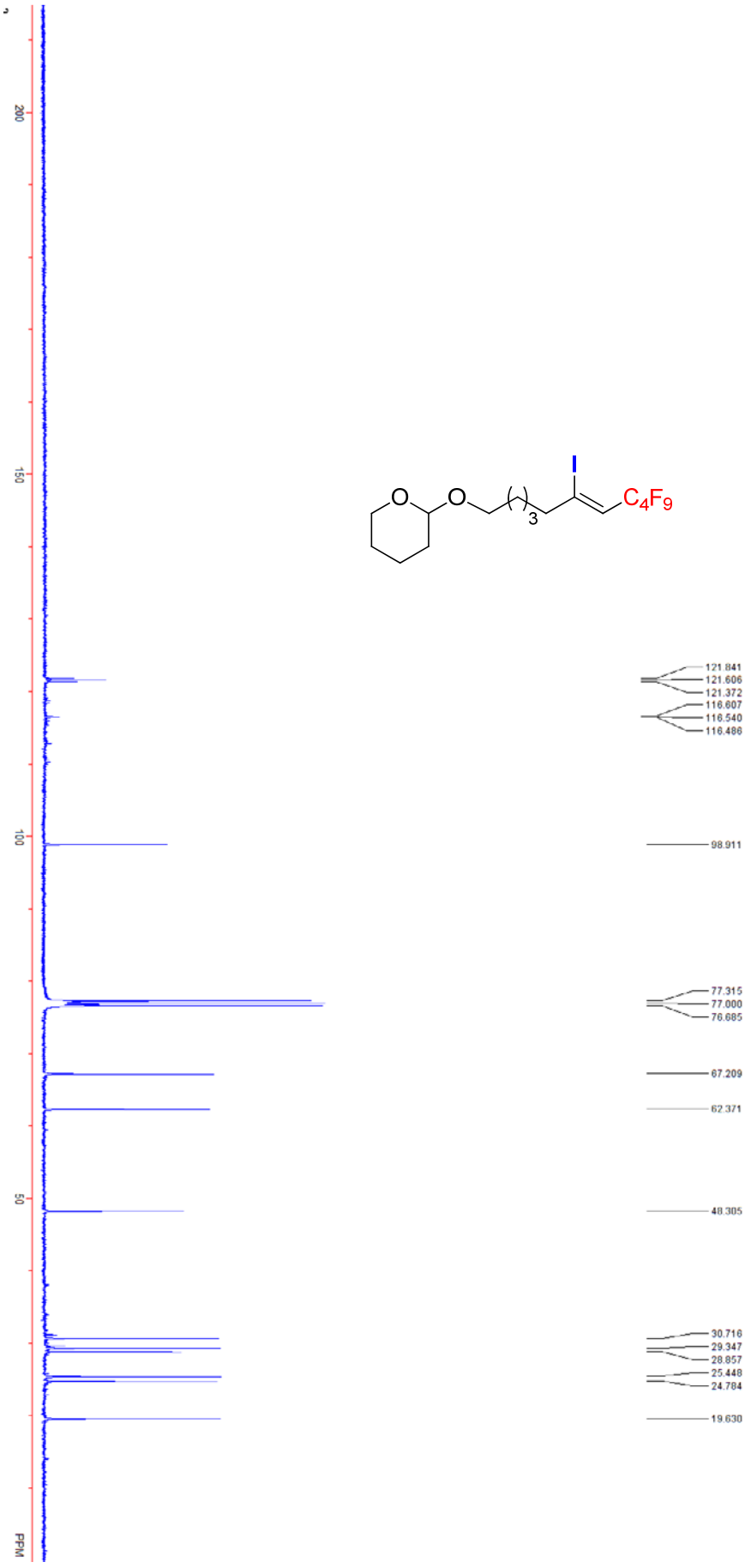
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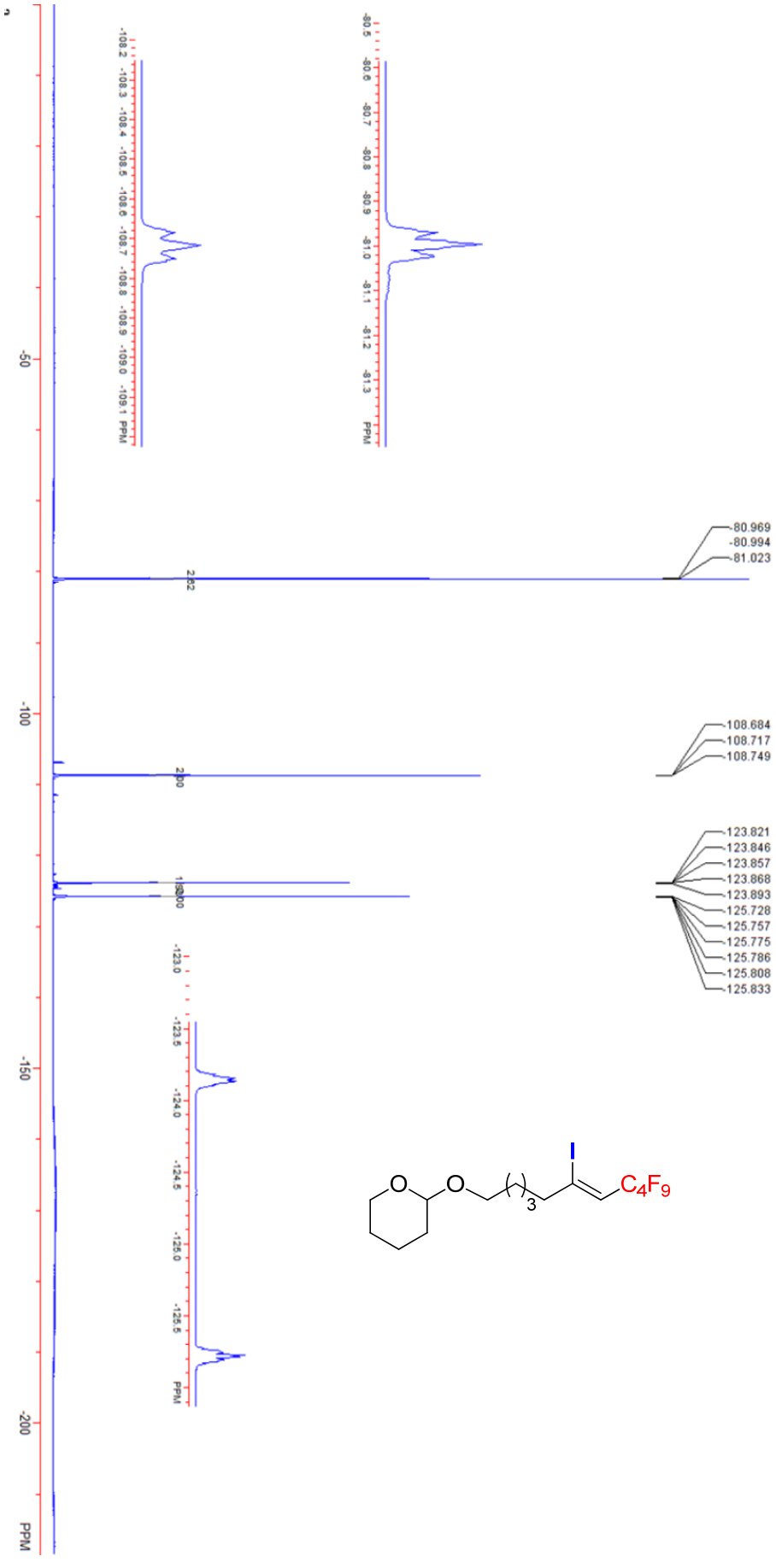
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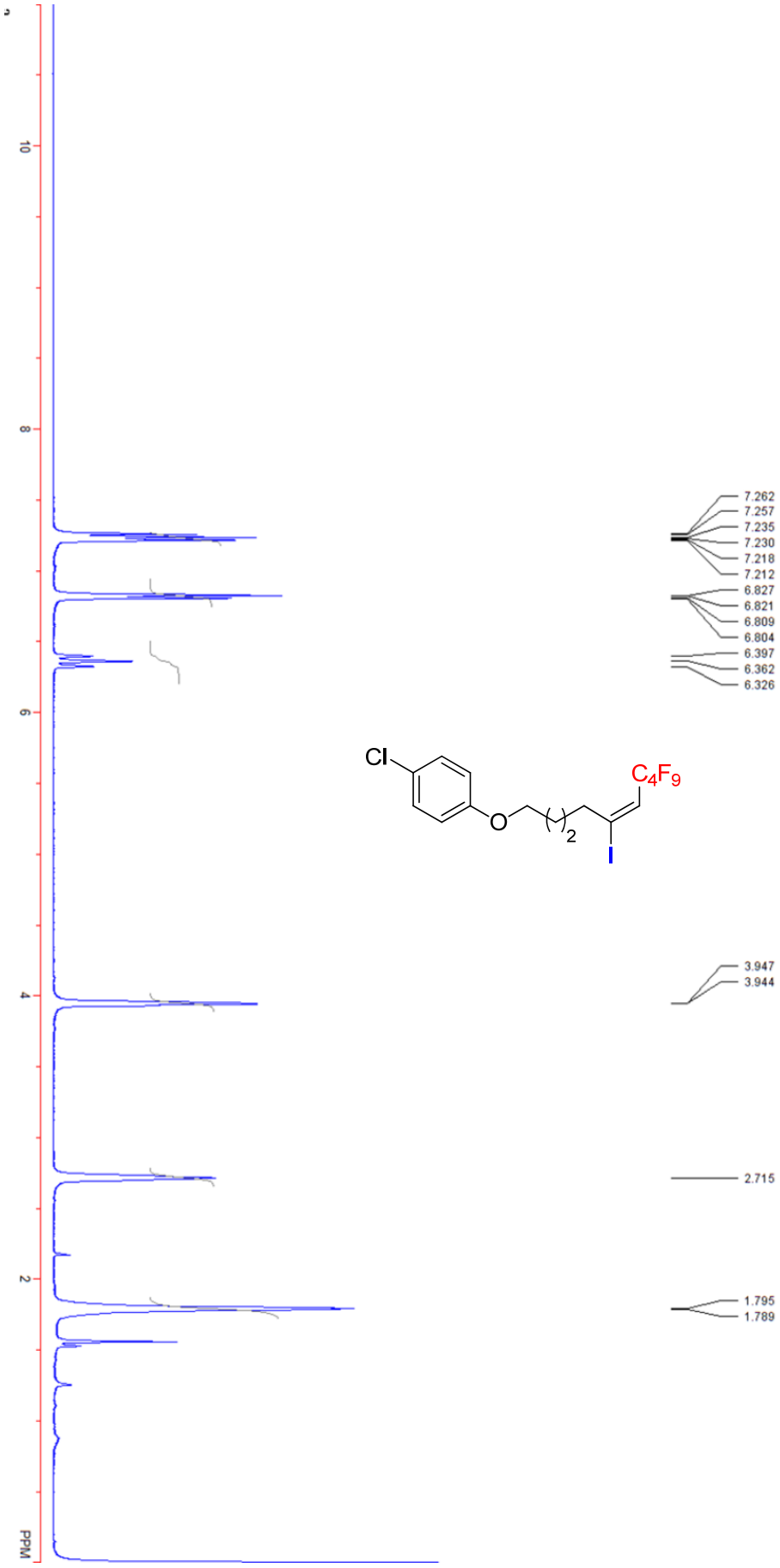
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Cl
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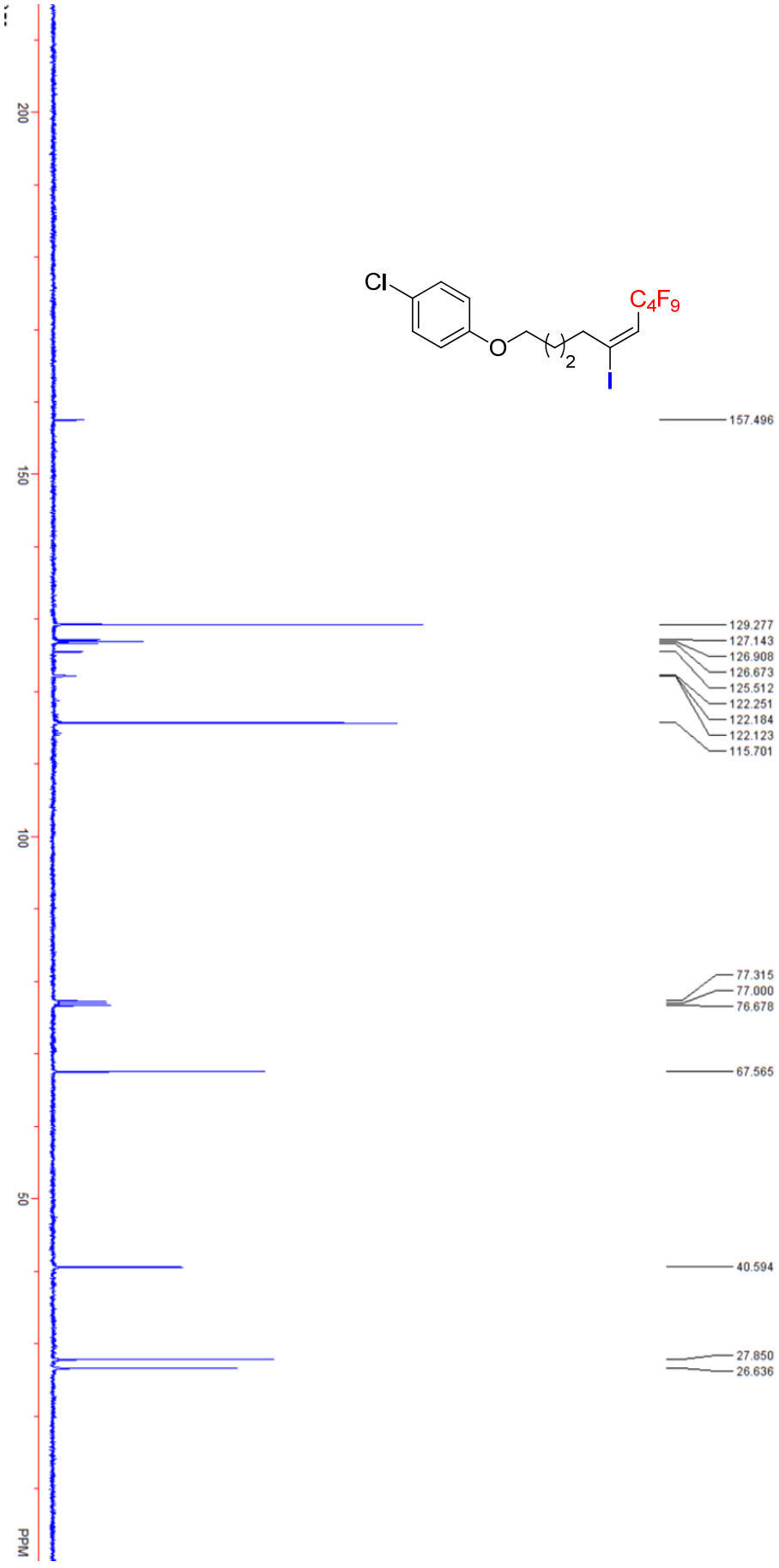
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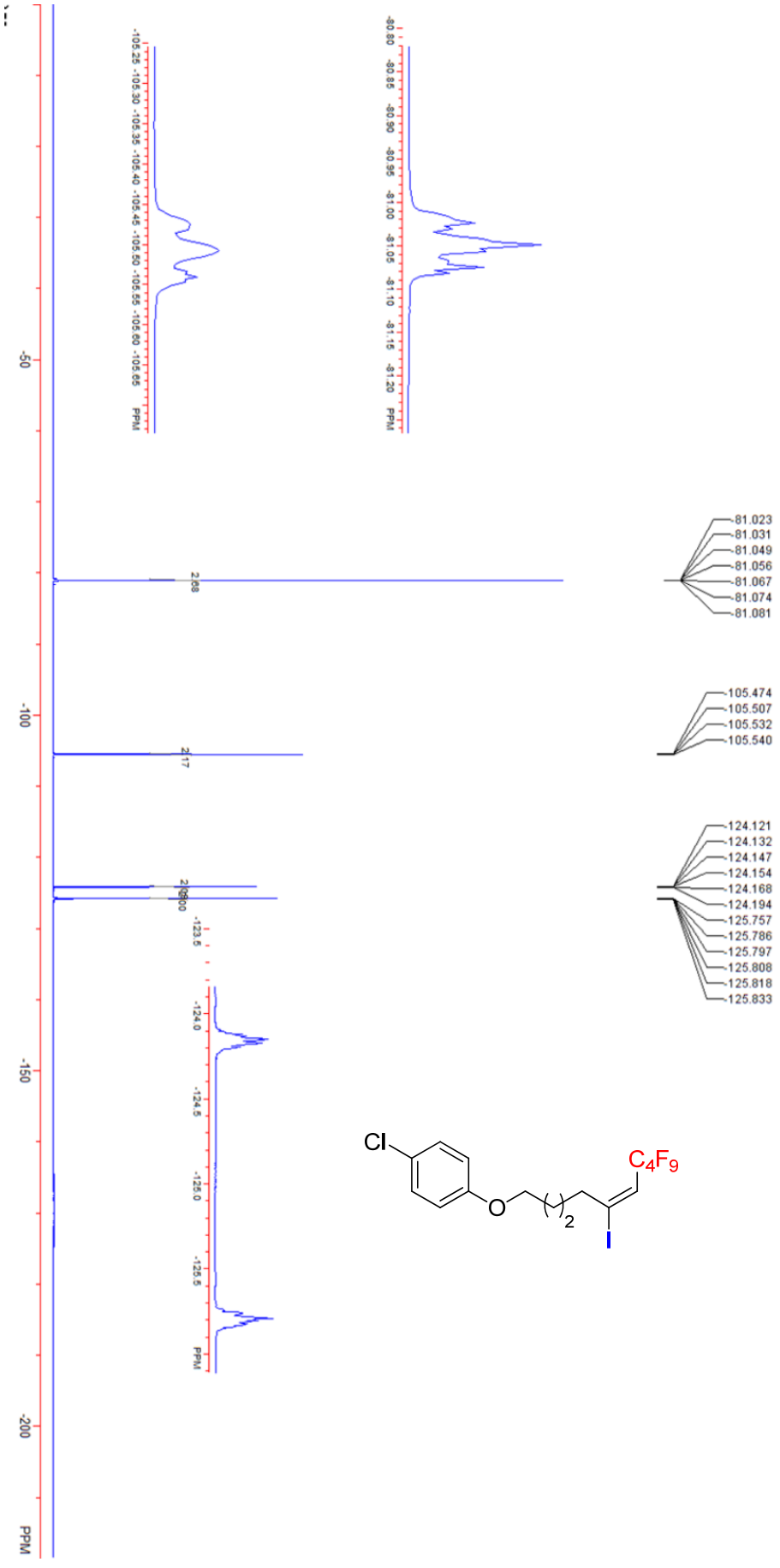
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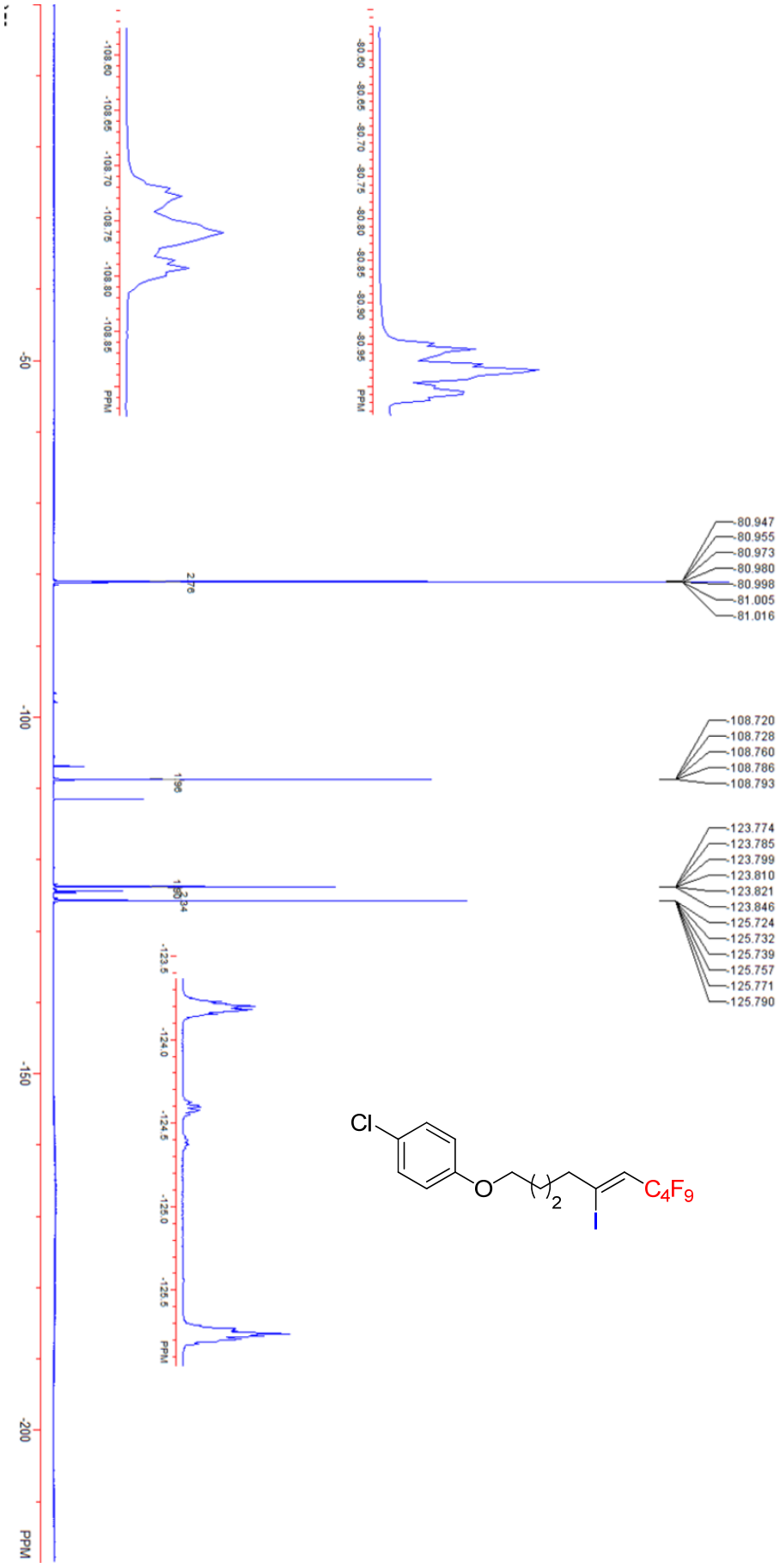
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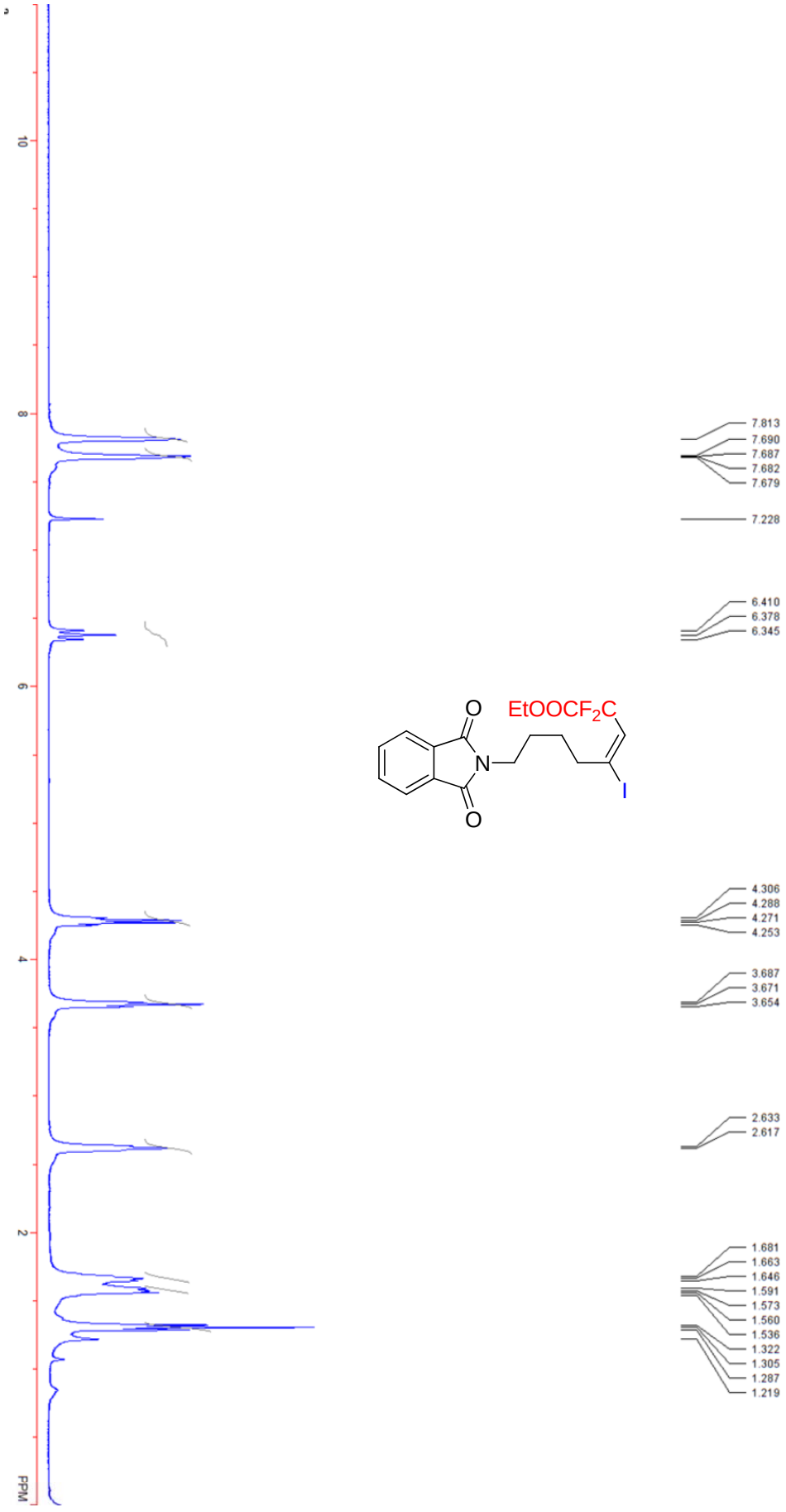
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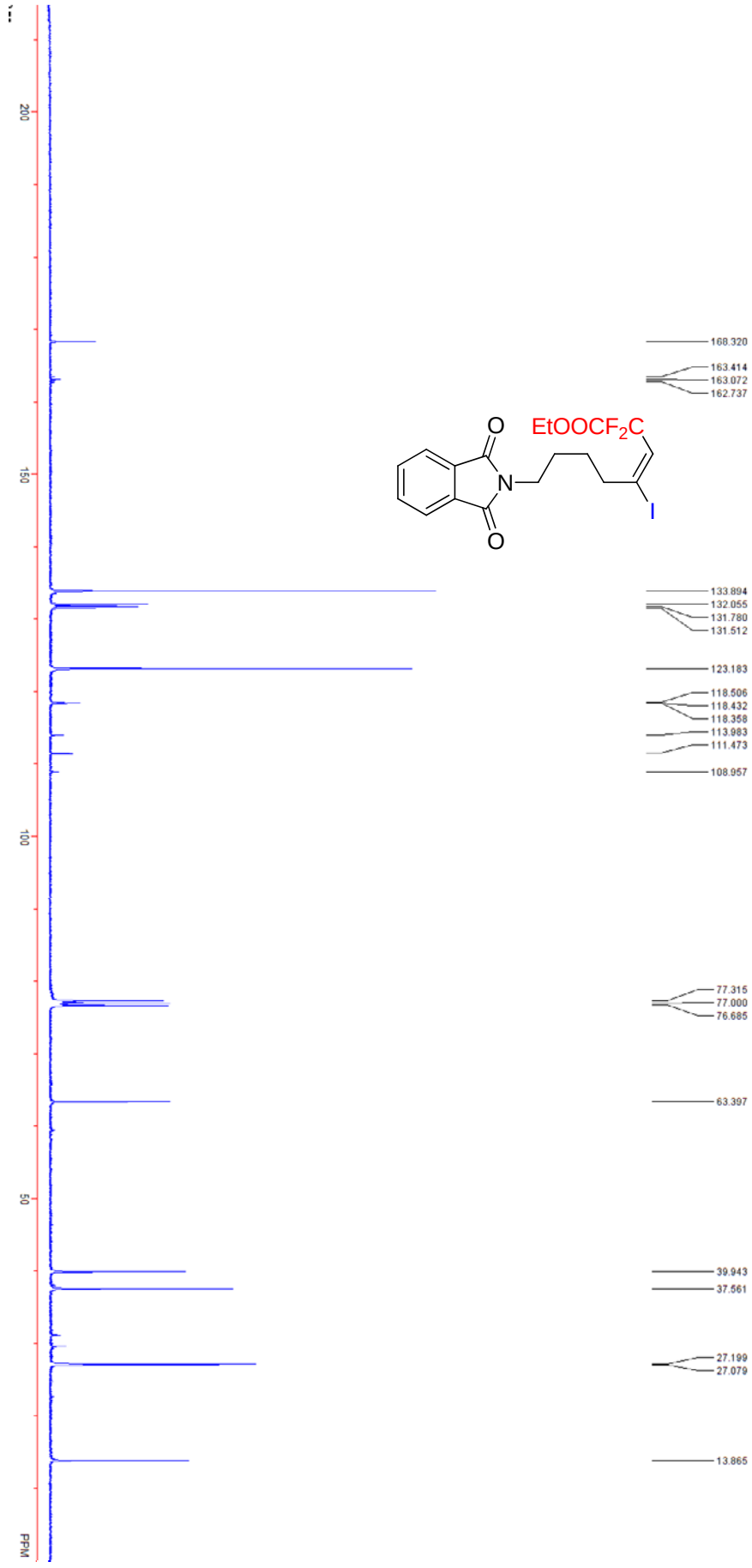
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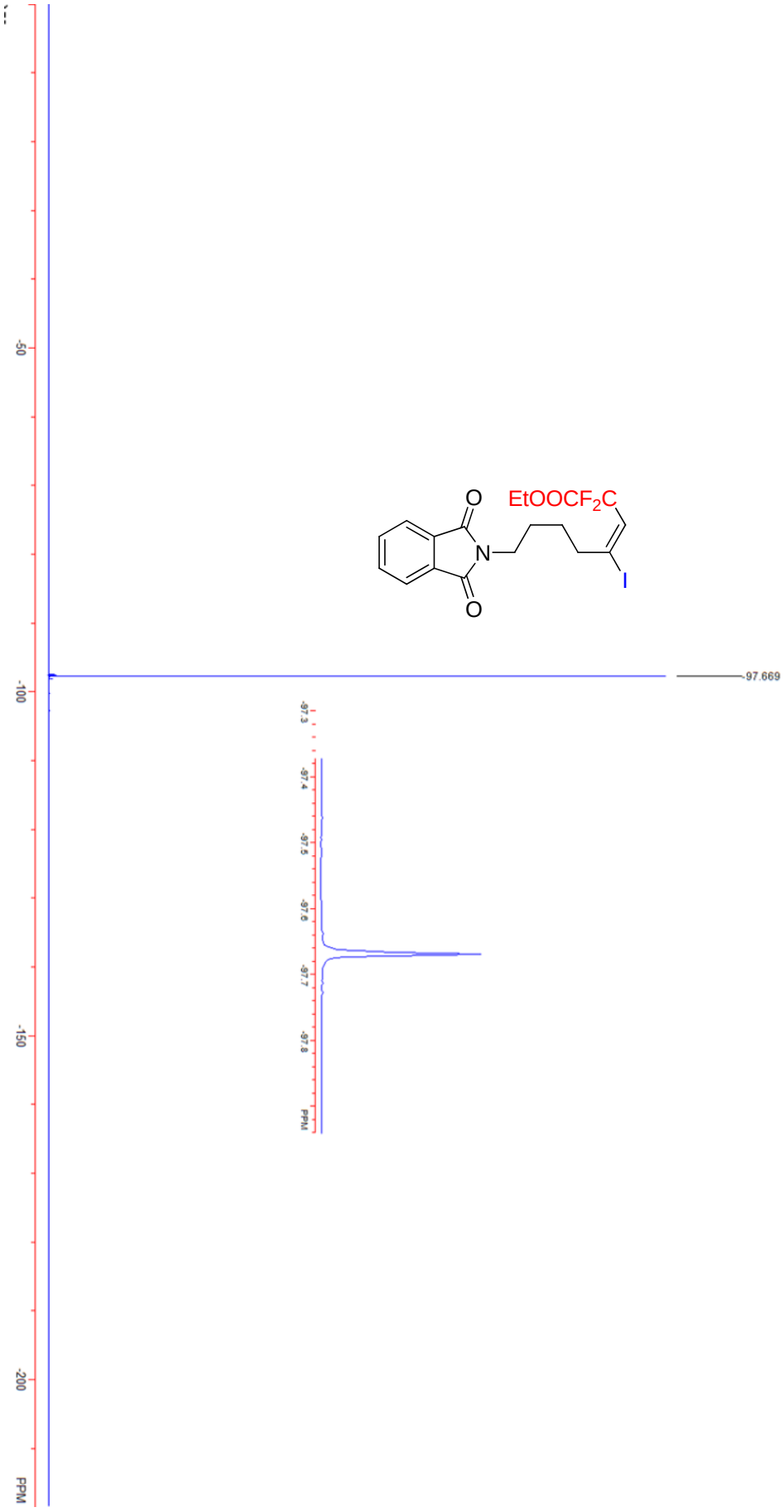
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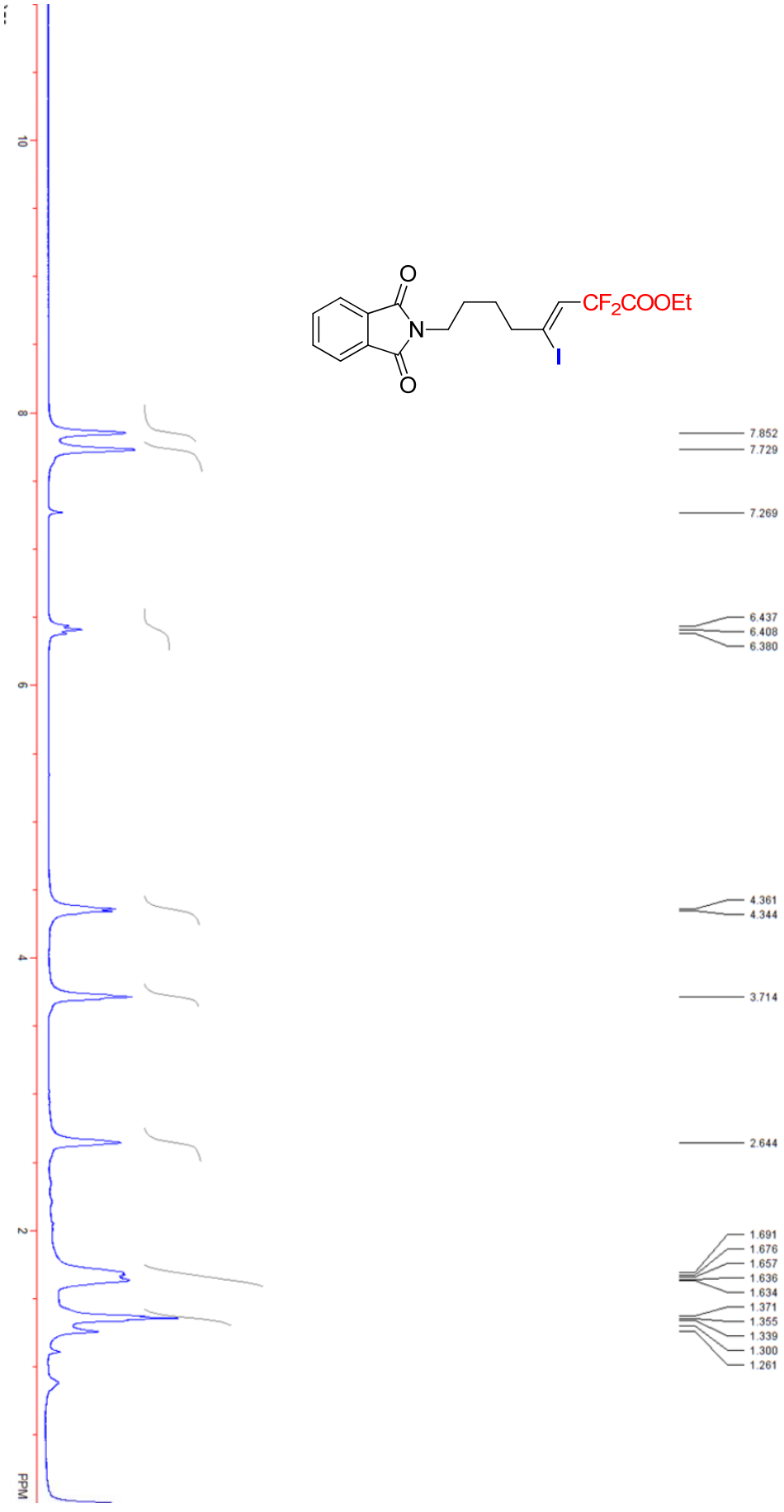
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1.676
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4
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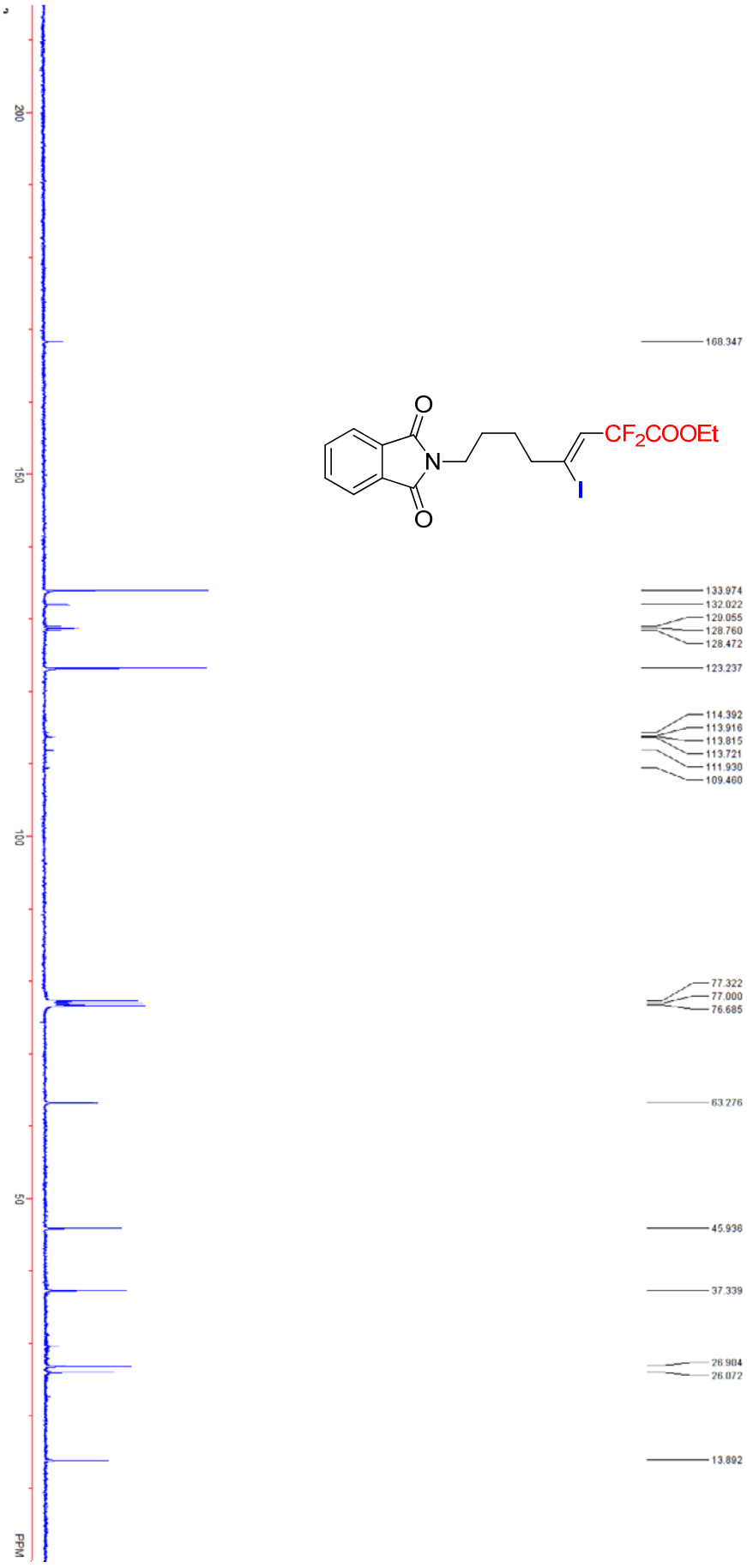
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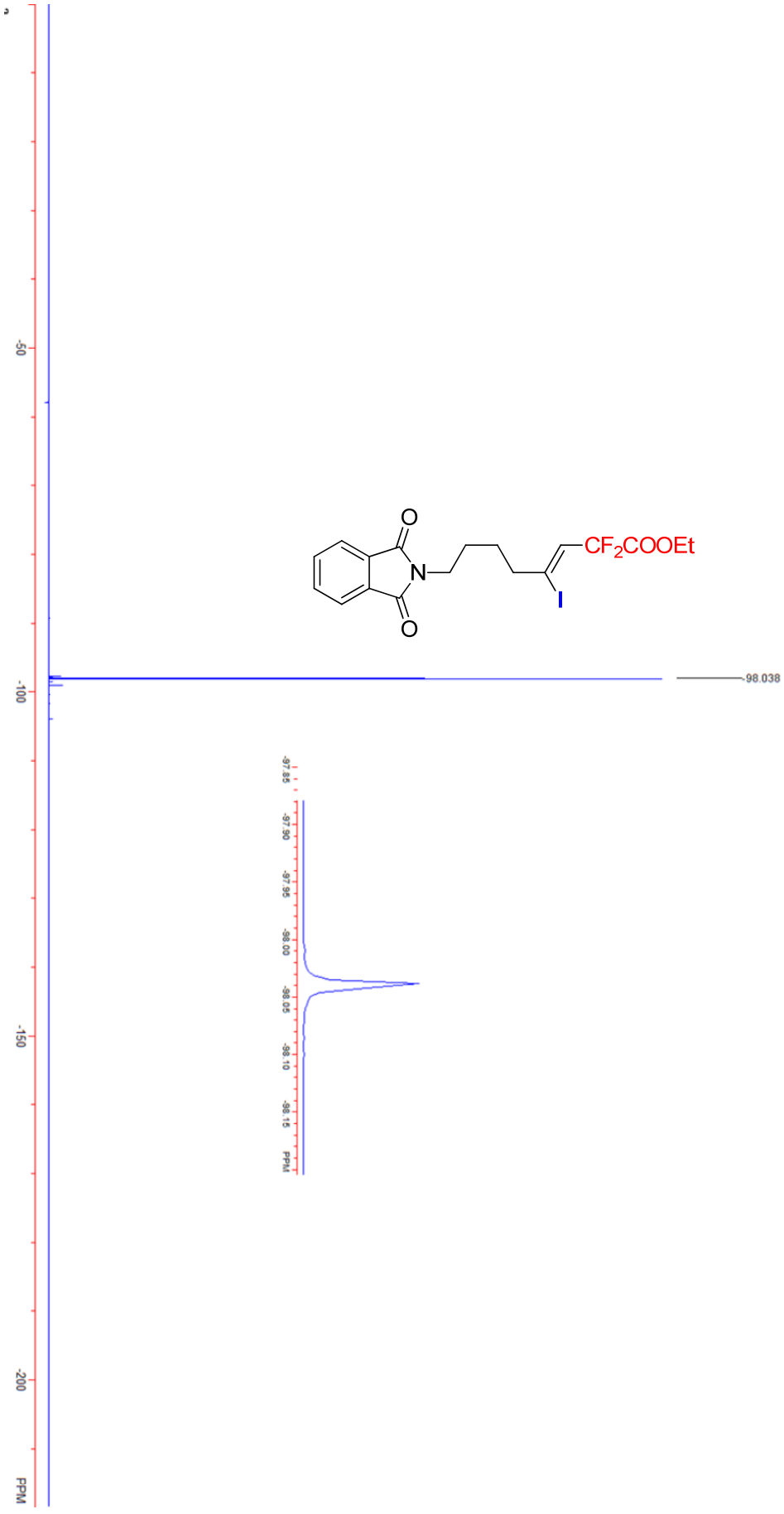
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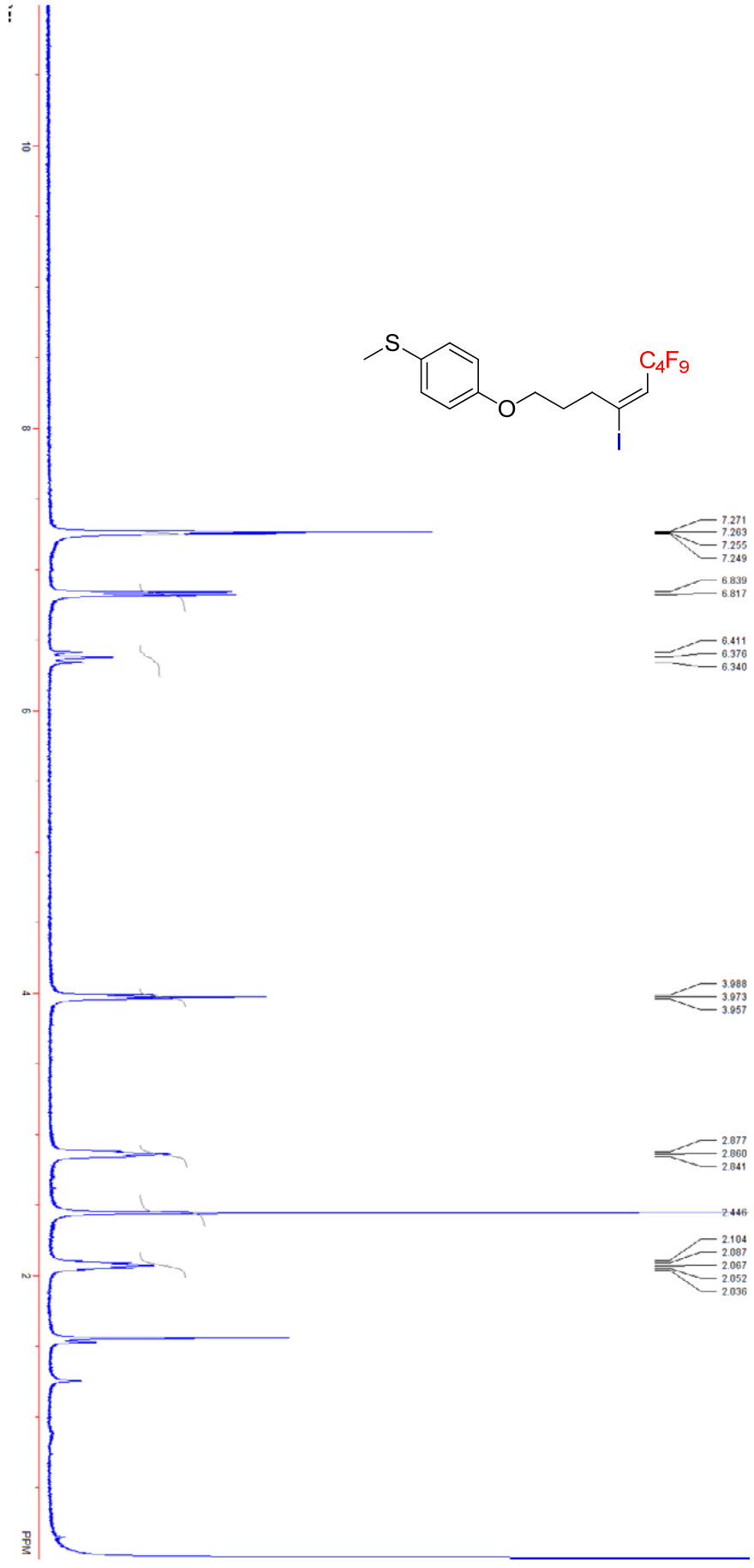
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3.973
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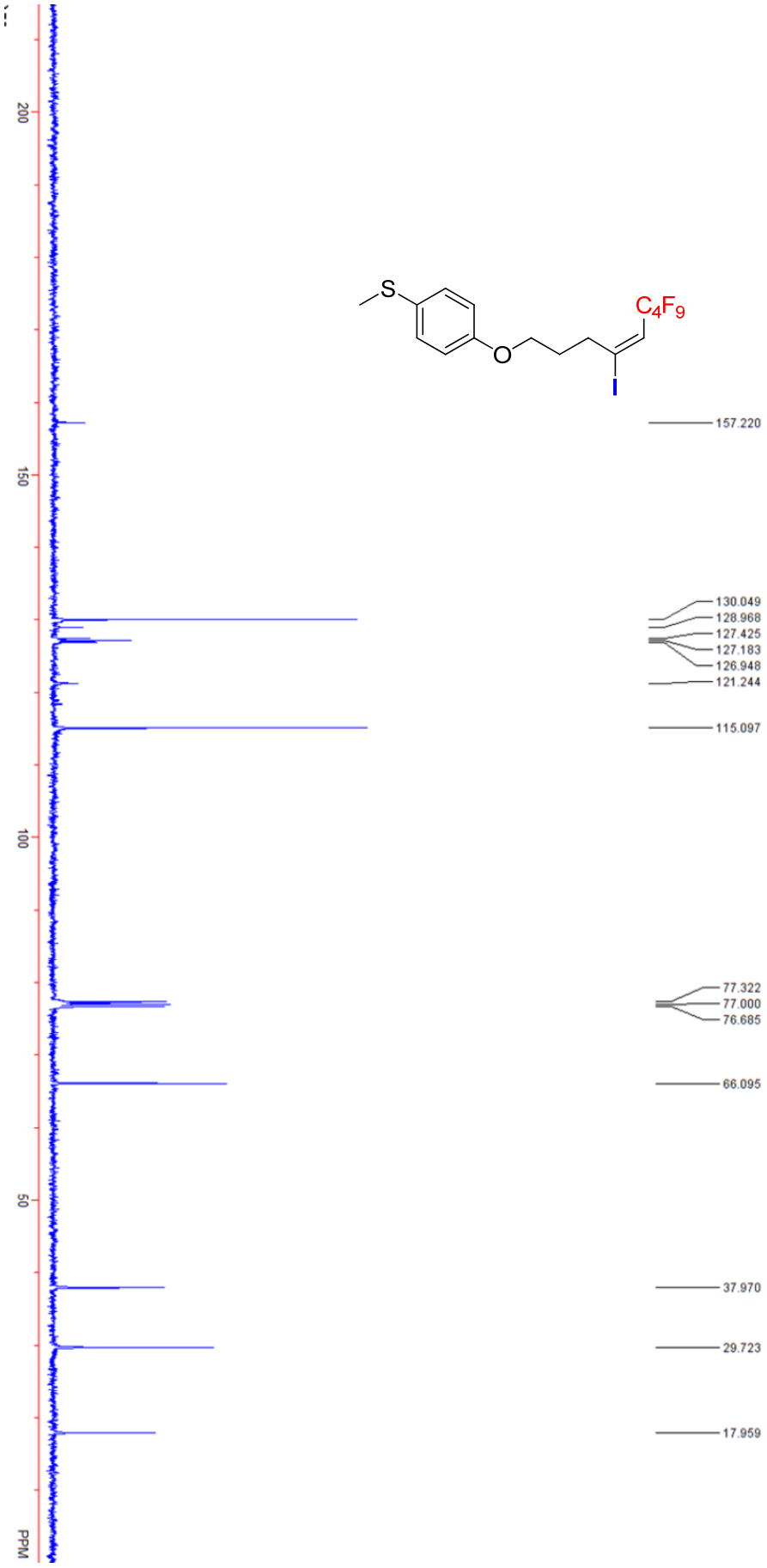
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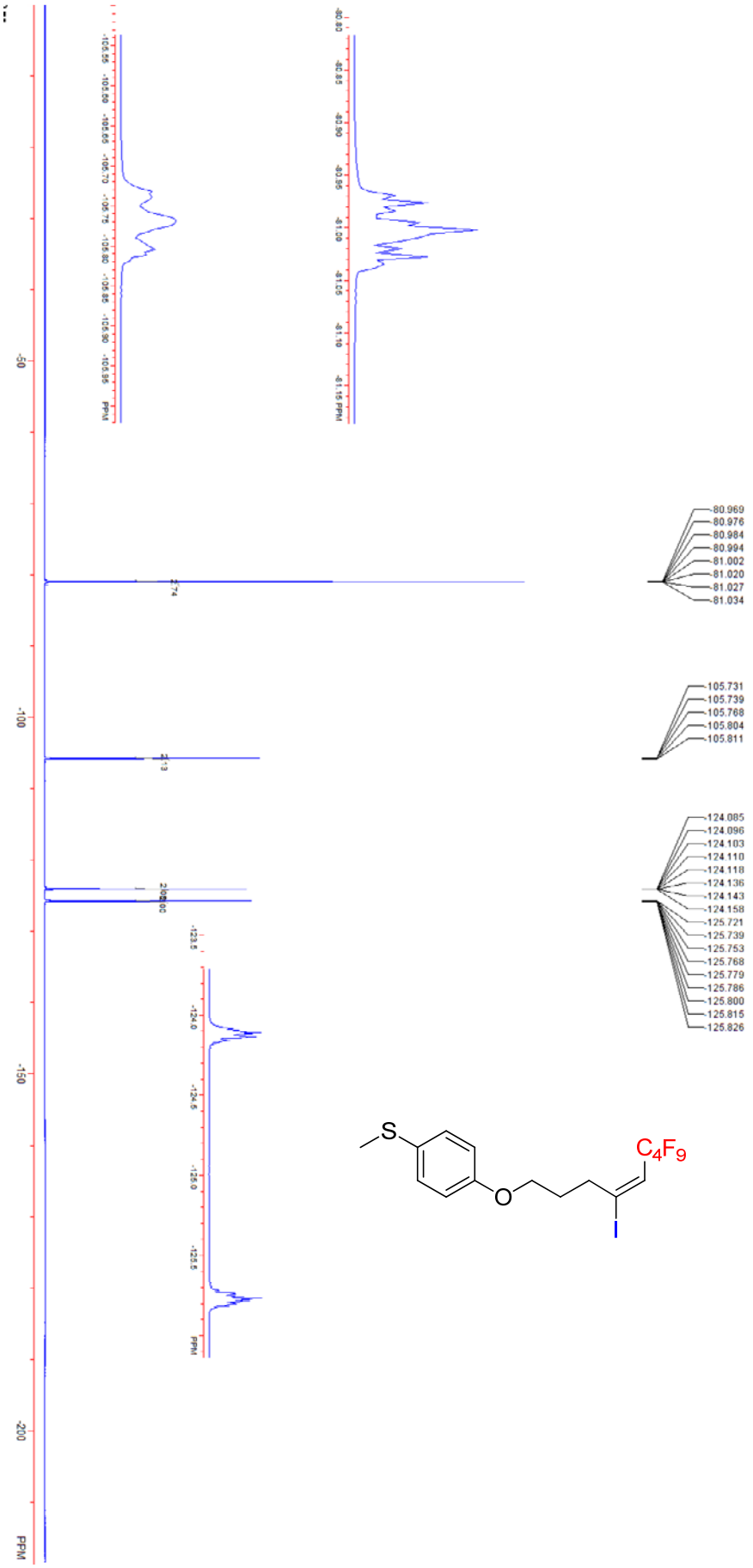
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C_4F_9
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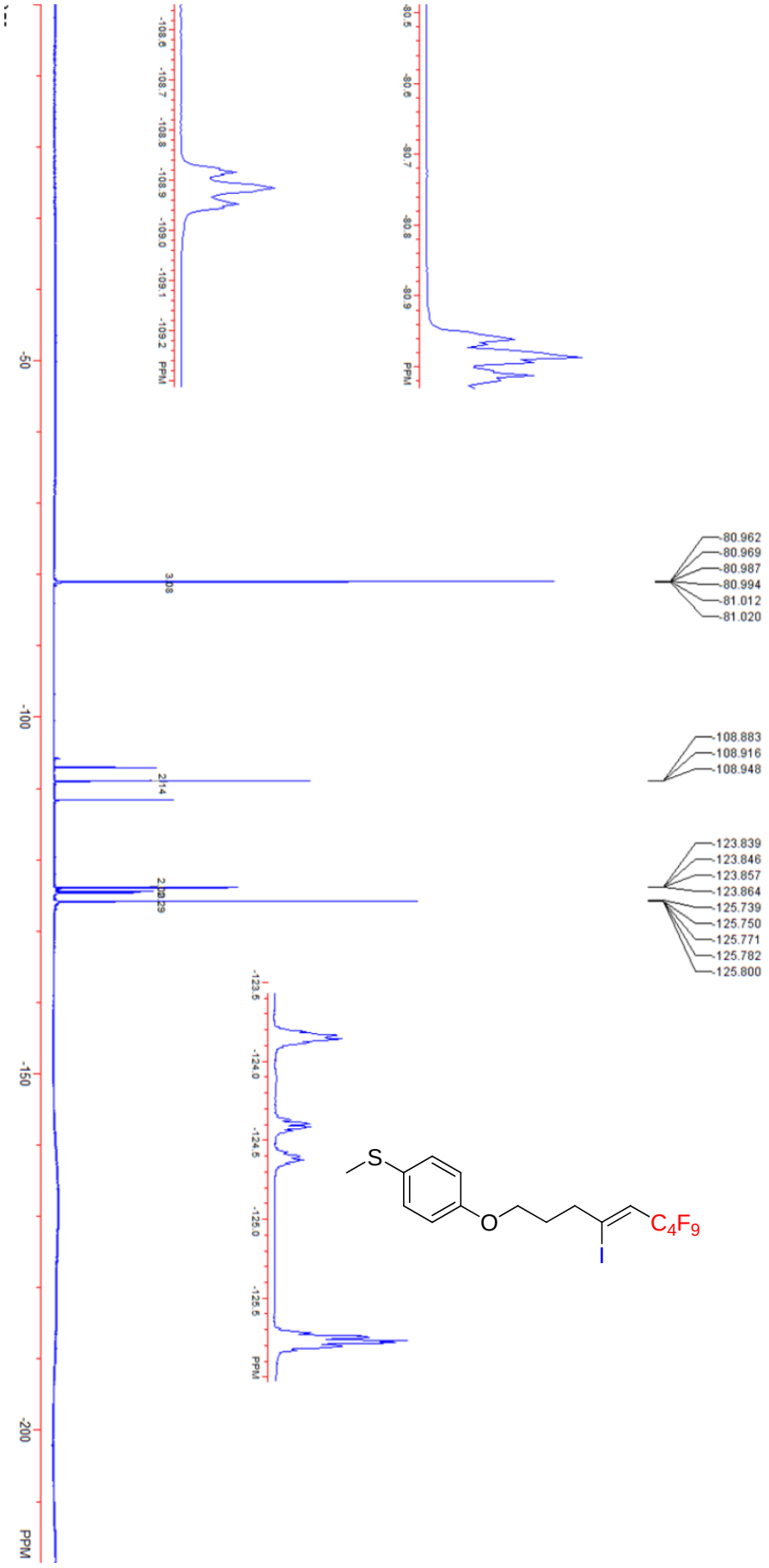
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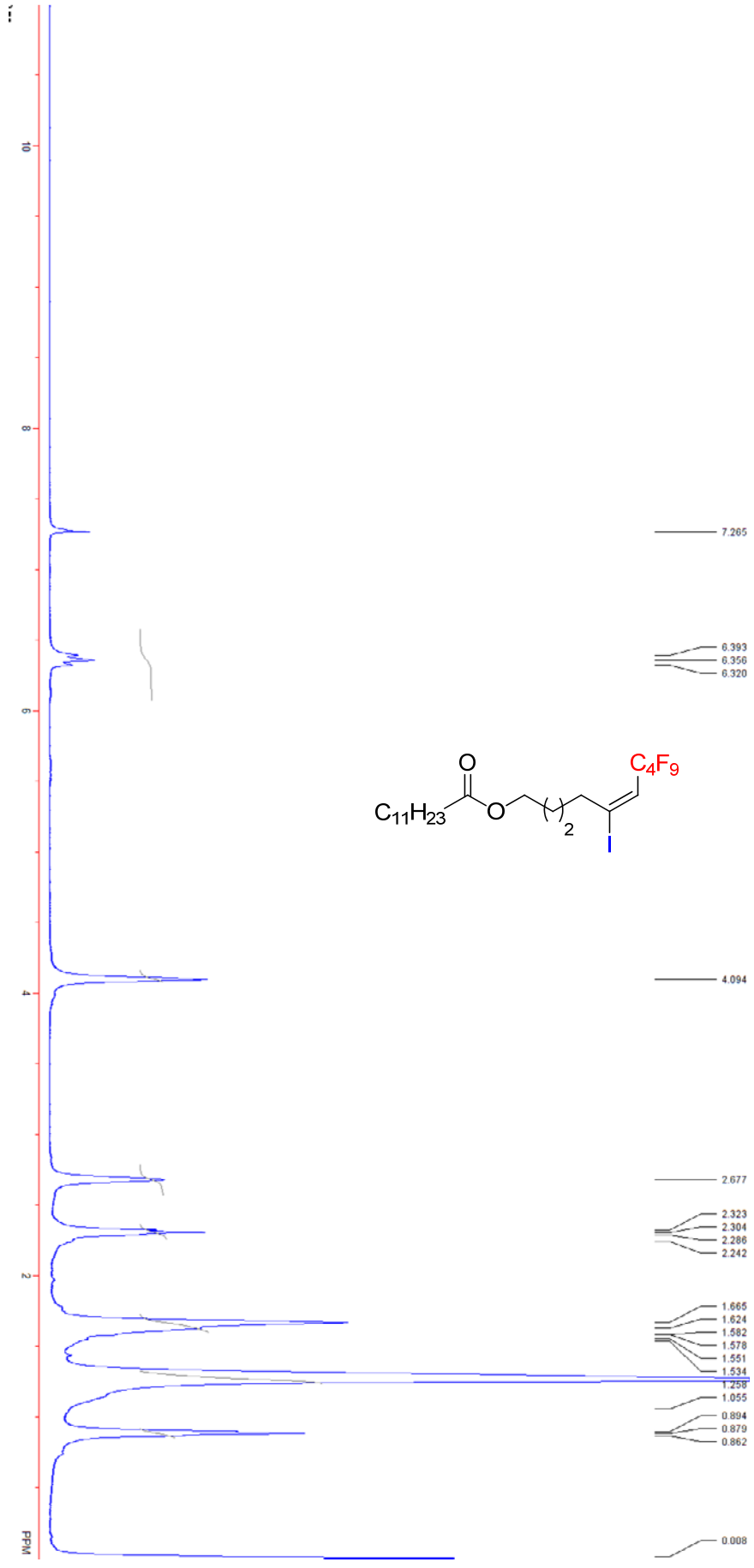
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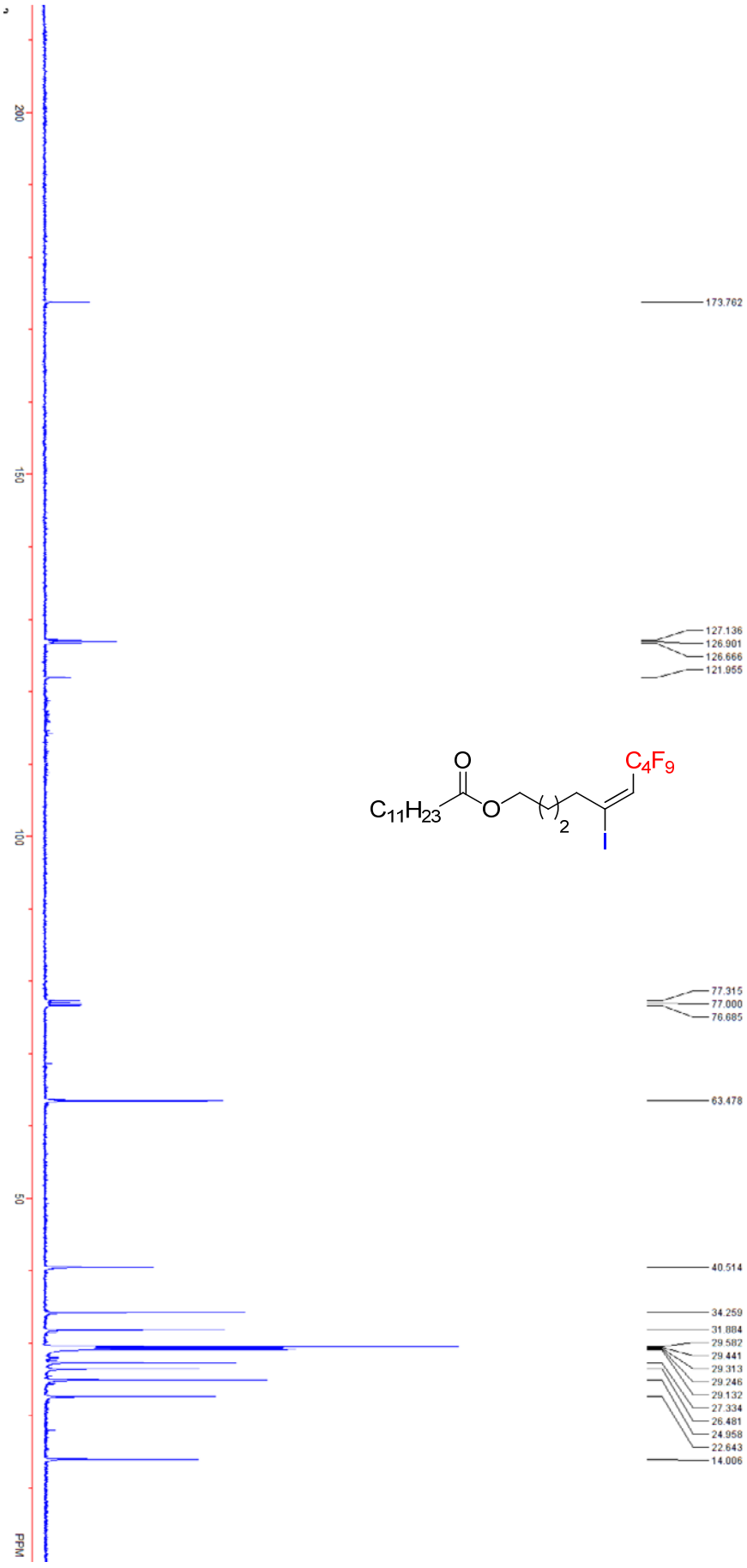
2
I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76.685
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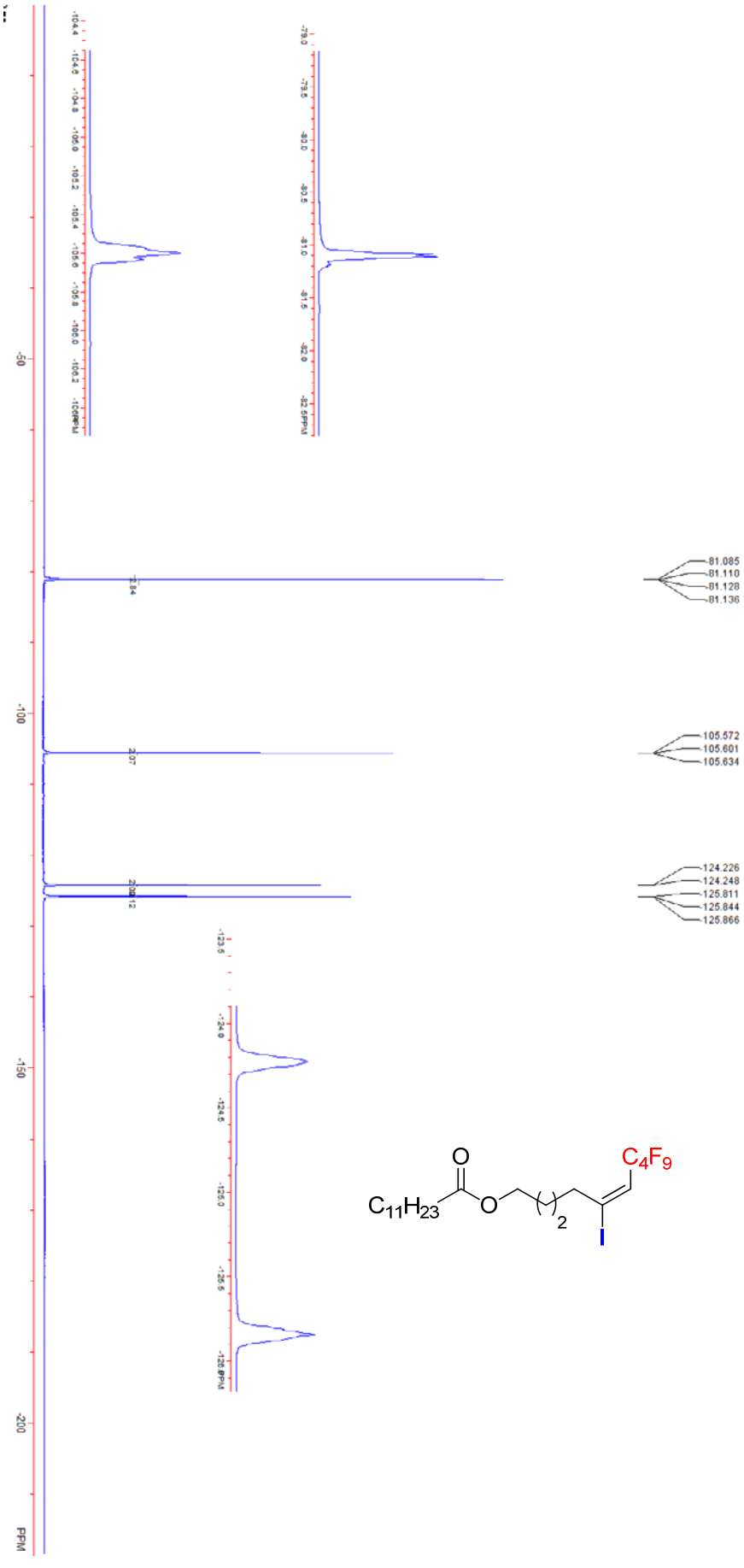
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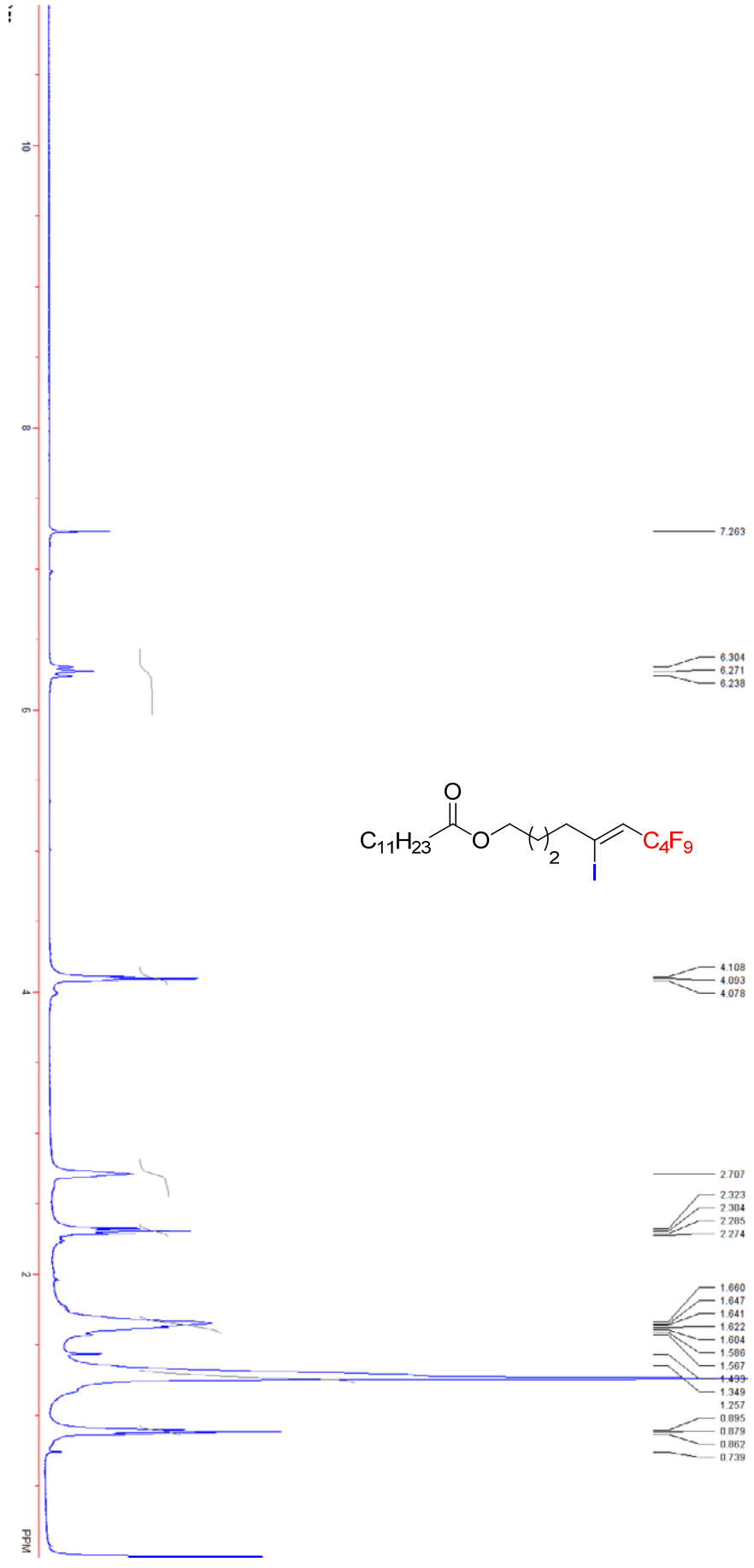
C_4F_9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2.285
2.274
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1.641
1.622
1.604
1.586
1.567
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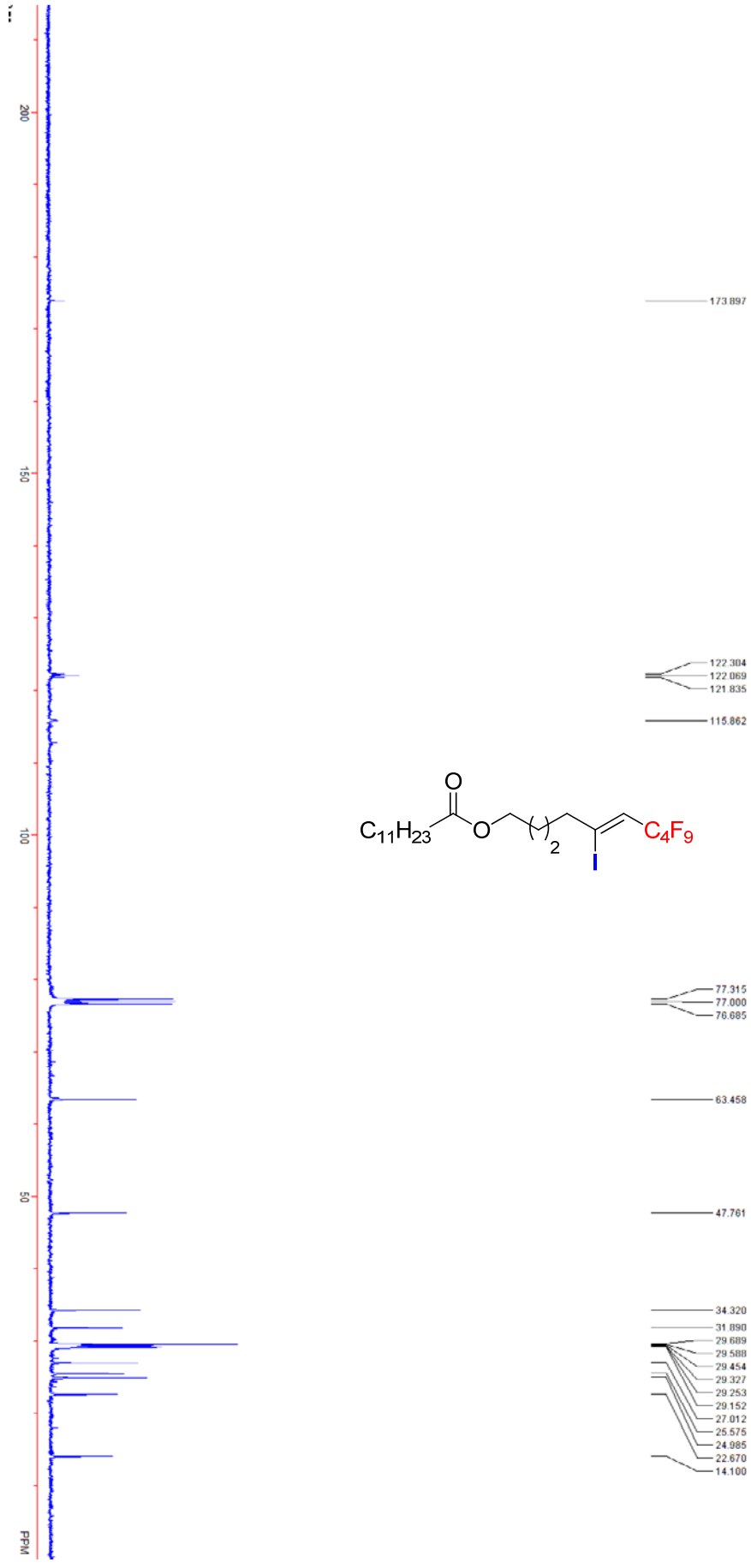
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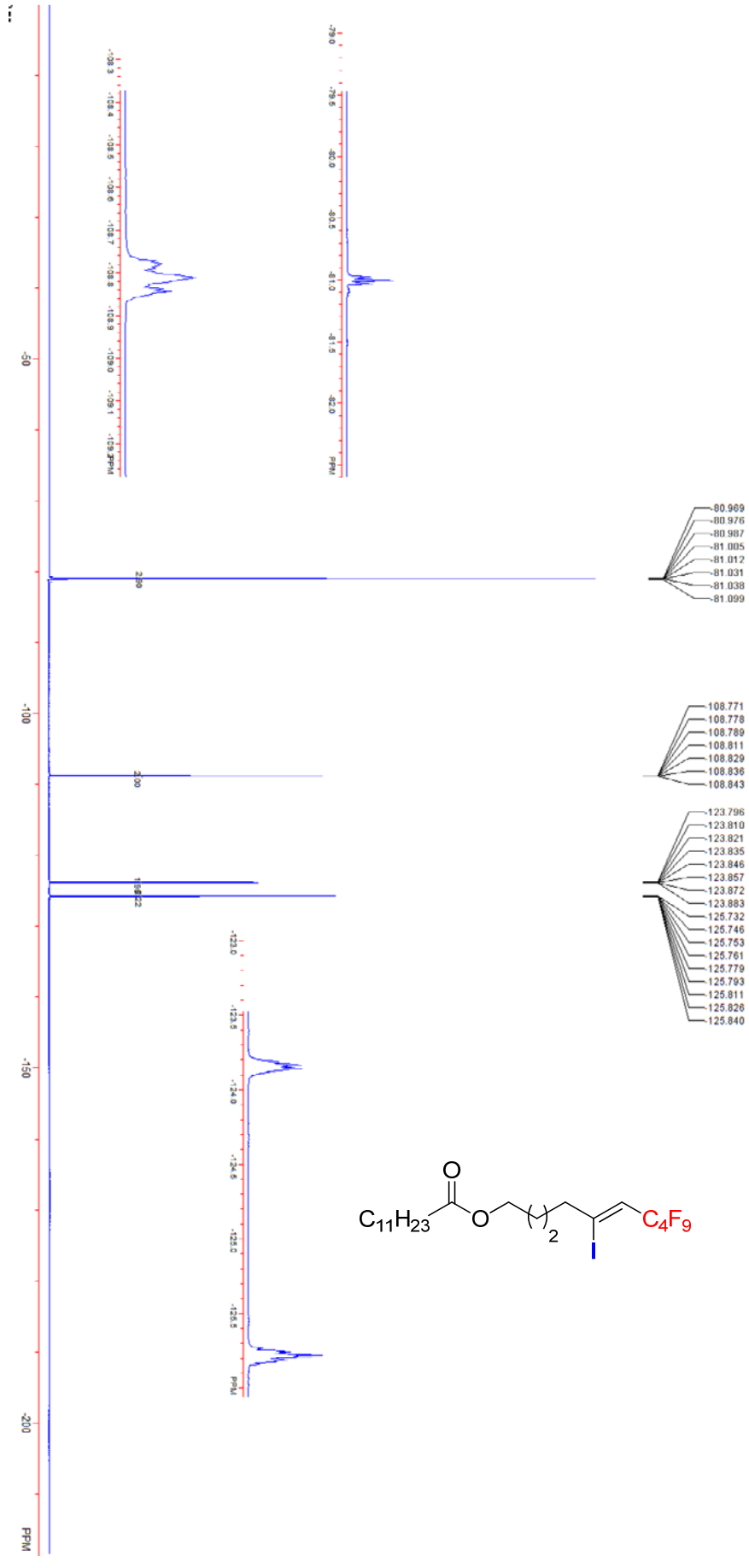
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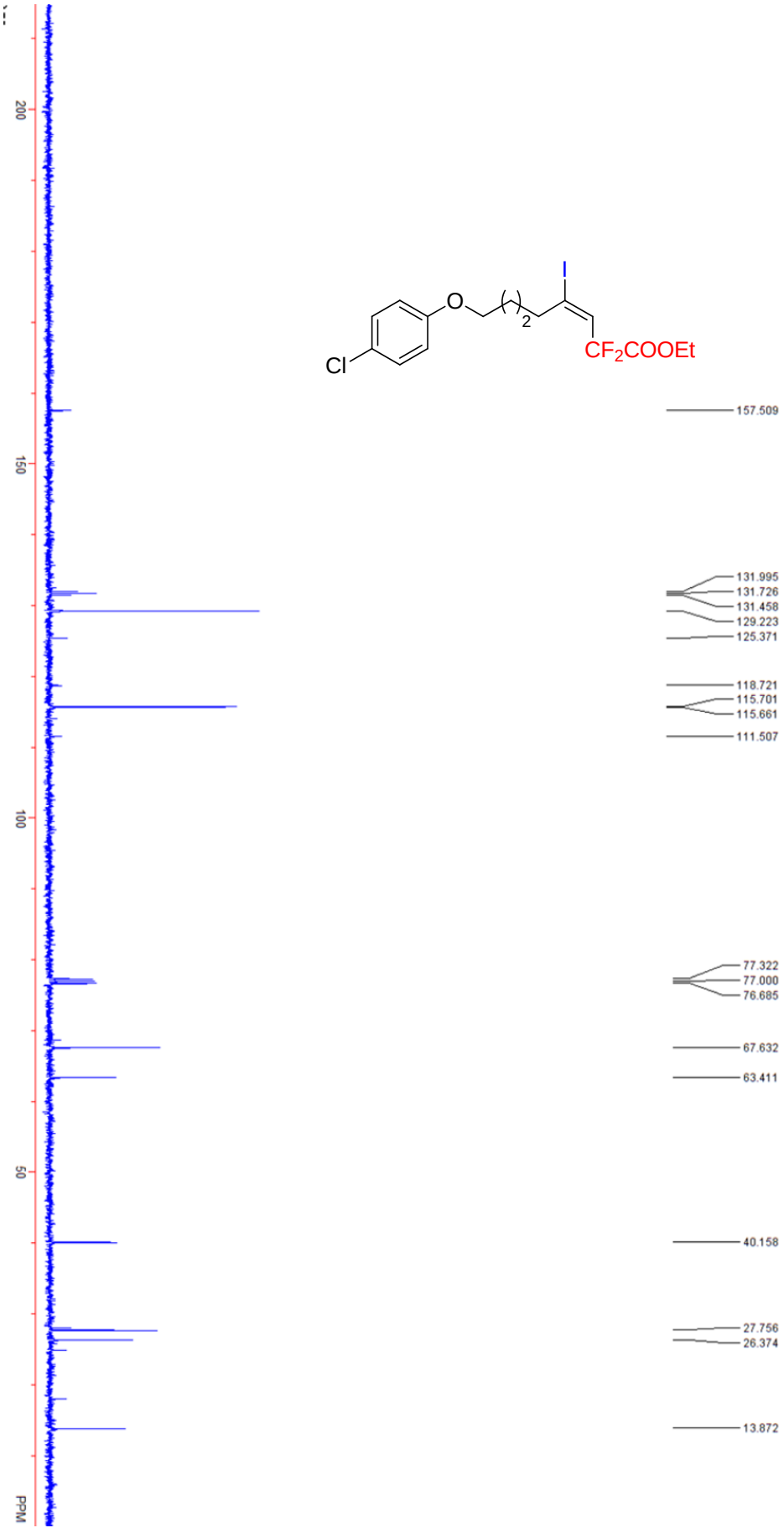
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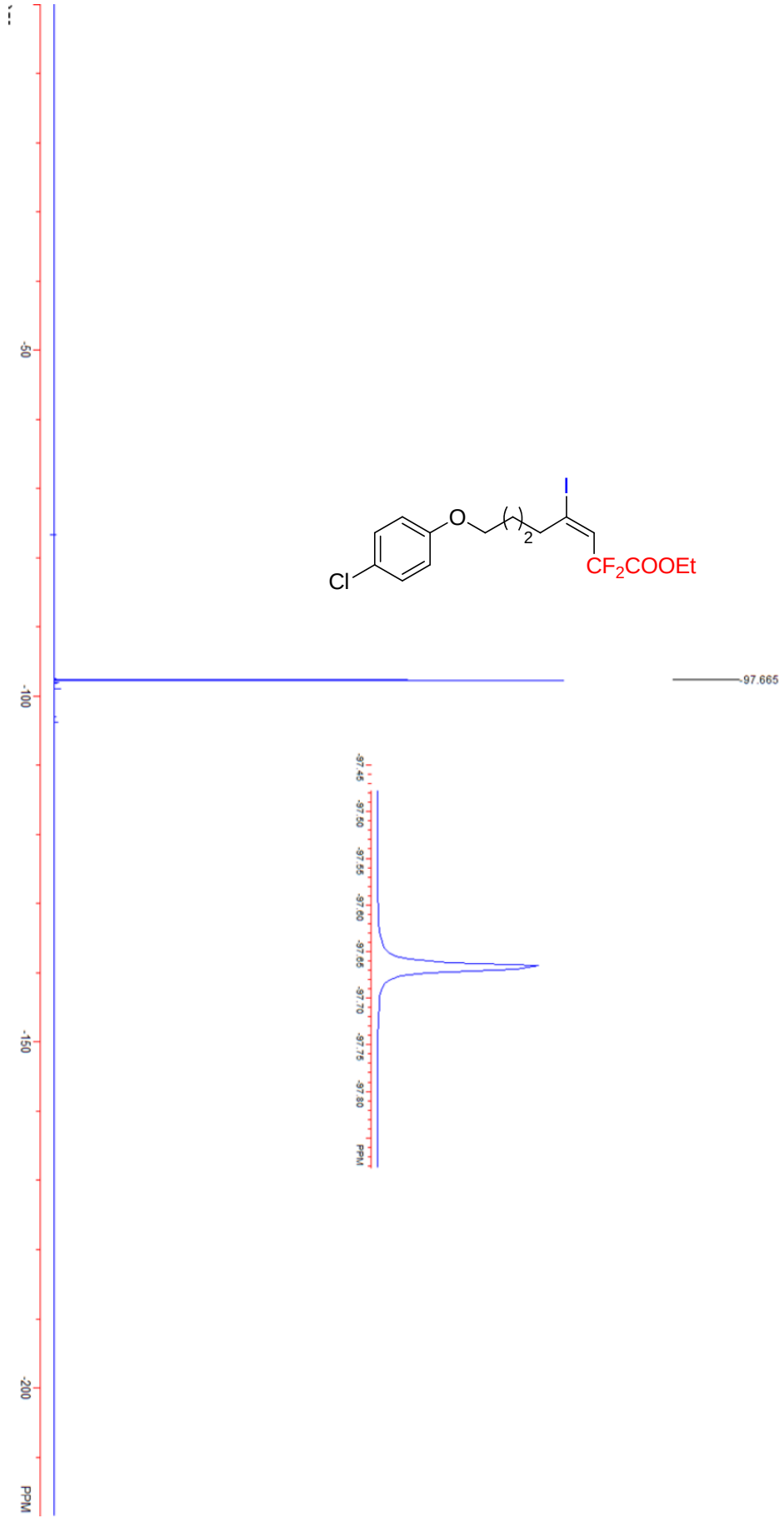
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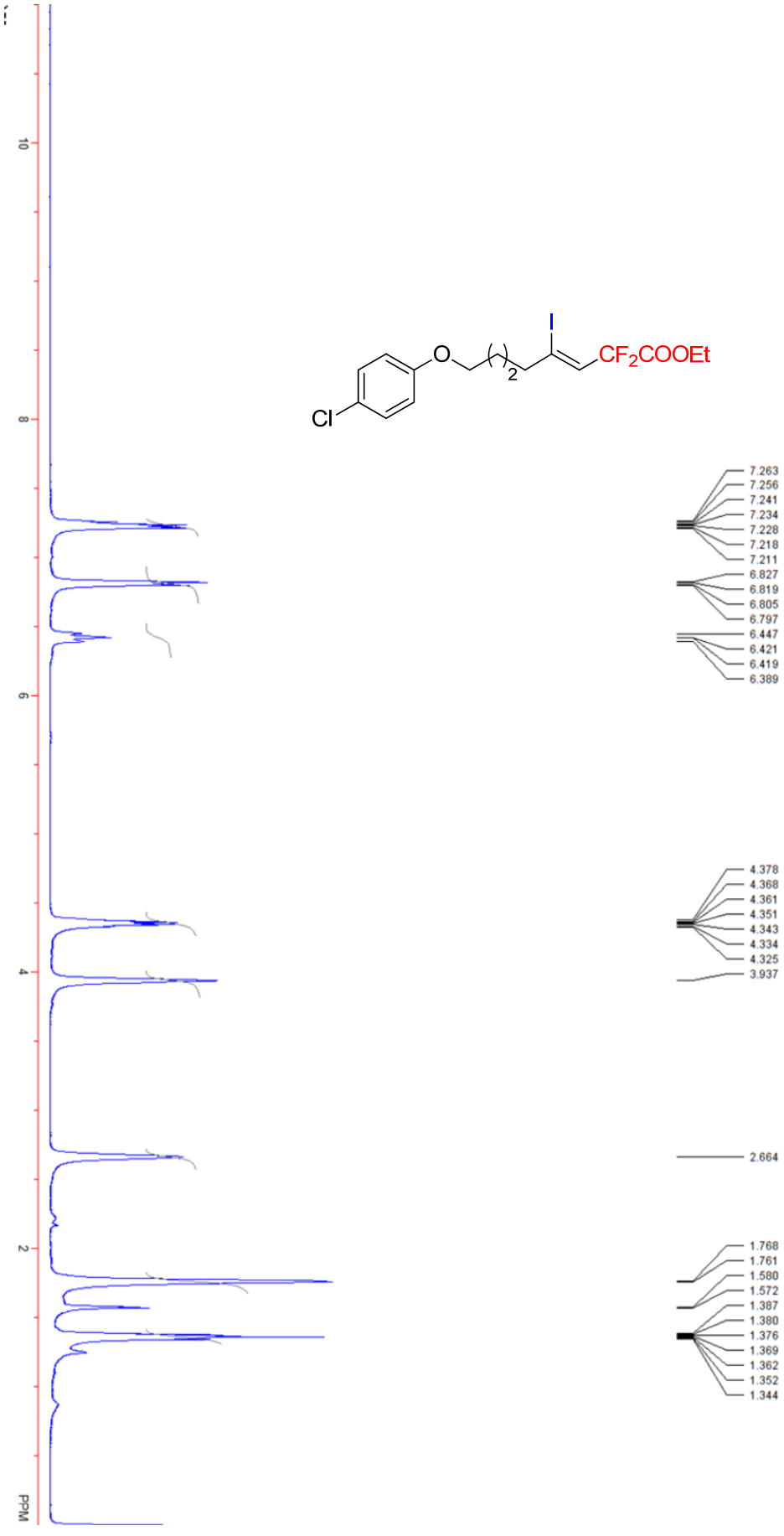
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2
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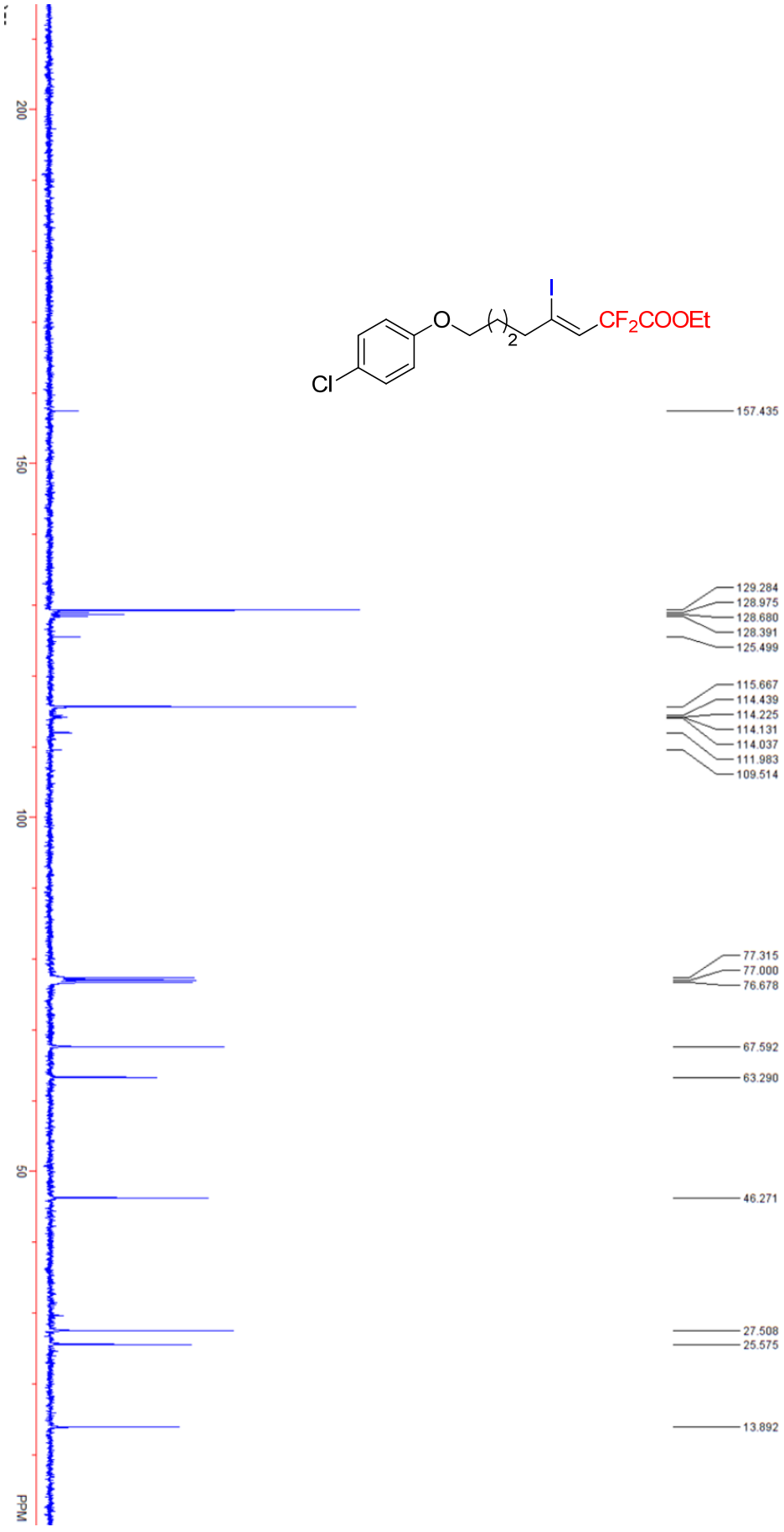
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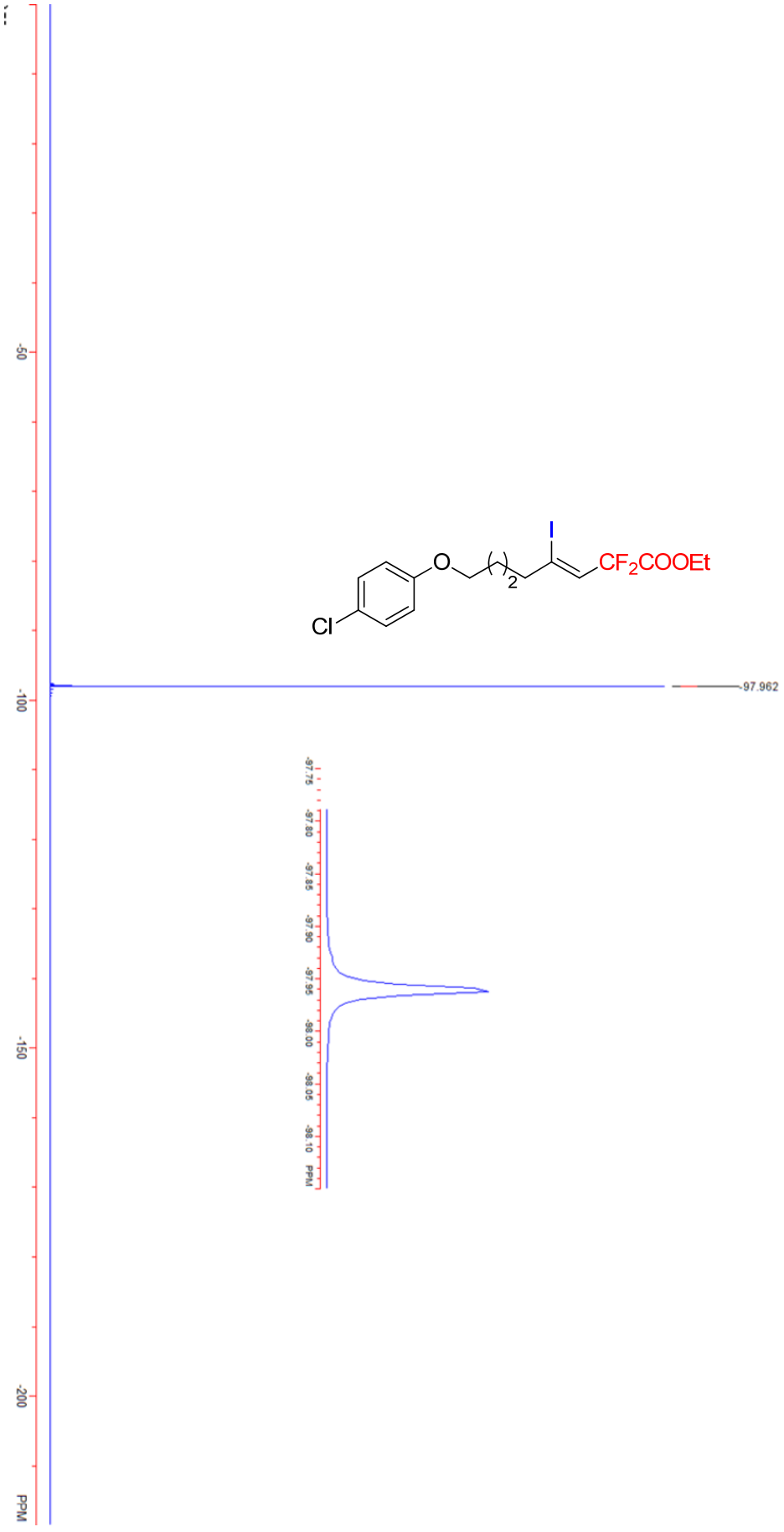
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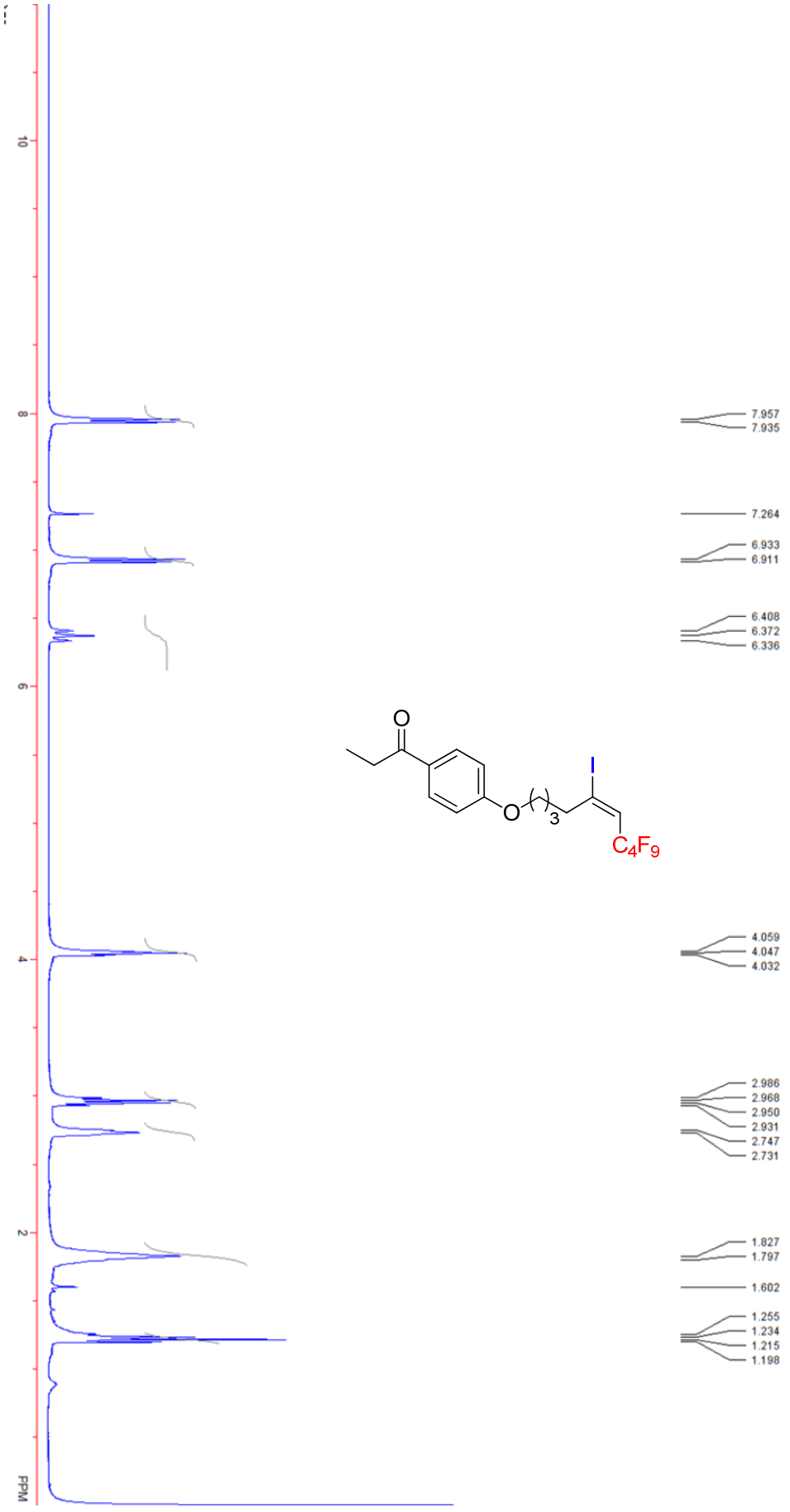
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2.731
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1.797
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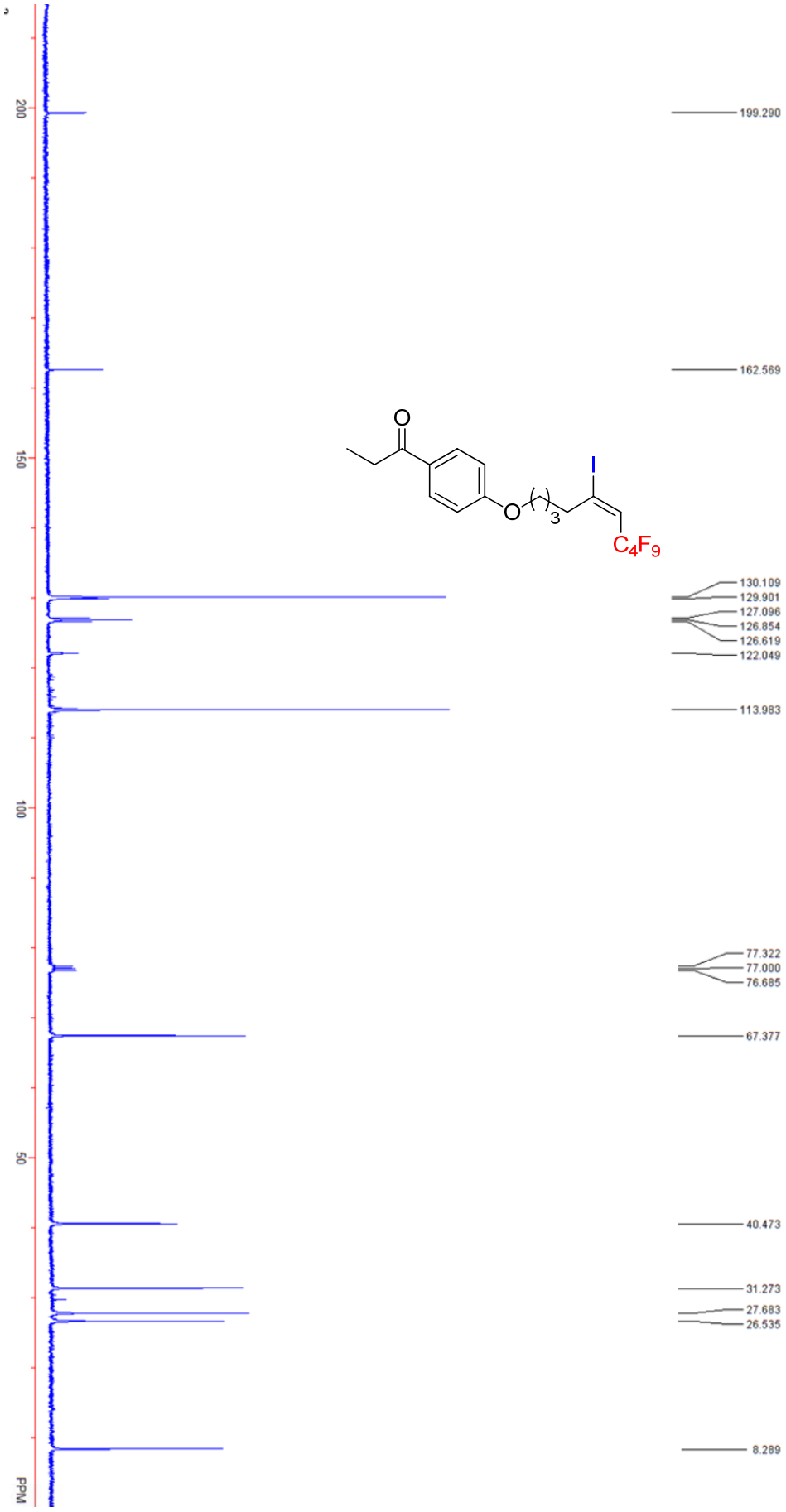
2
PPM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26.535
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50
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3
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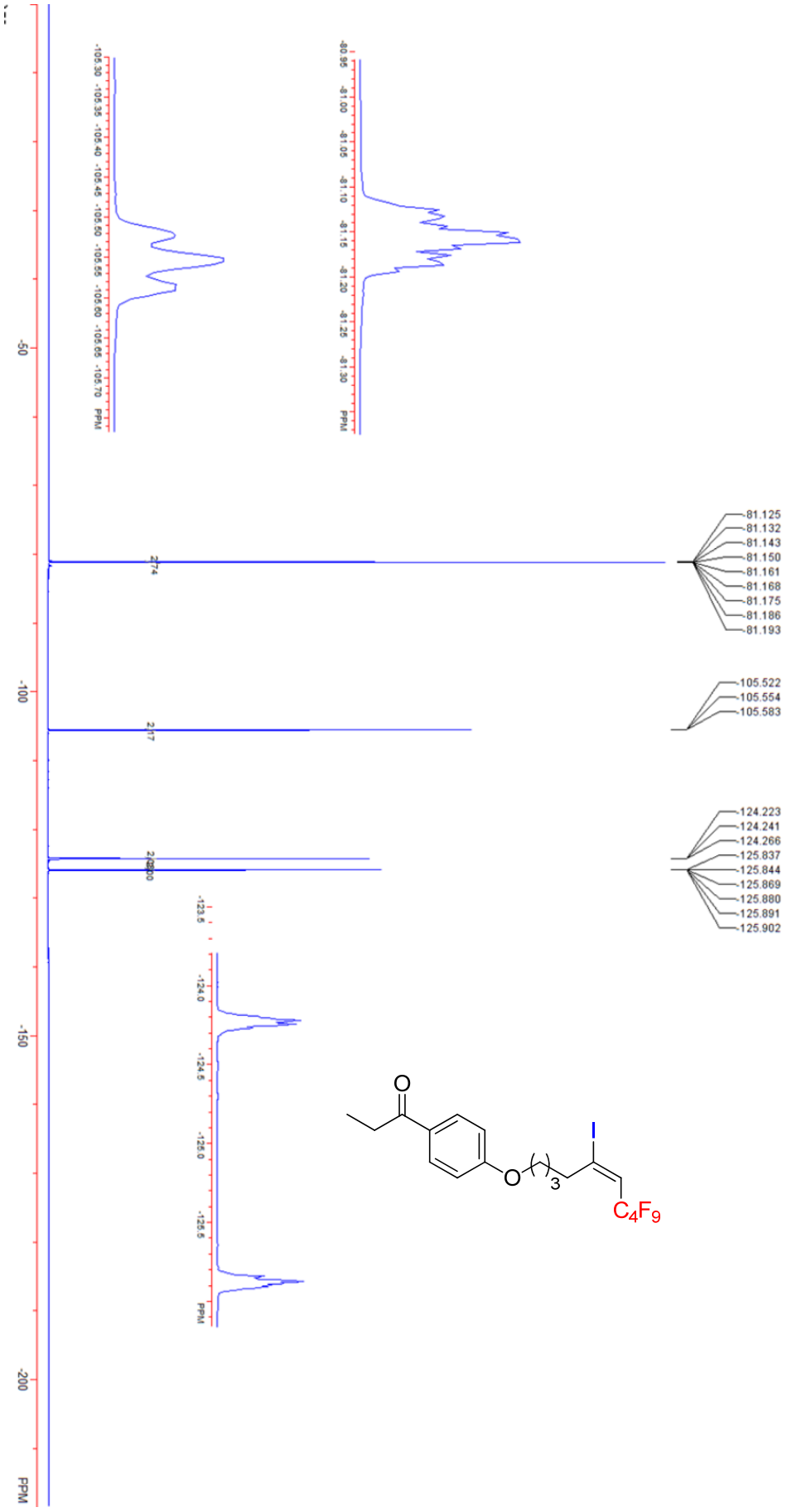
C4F9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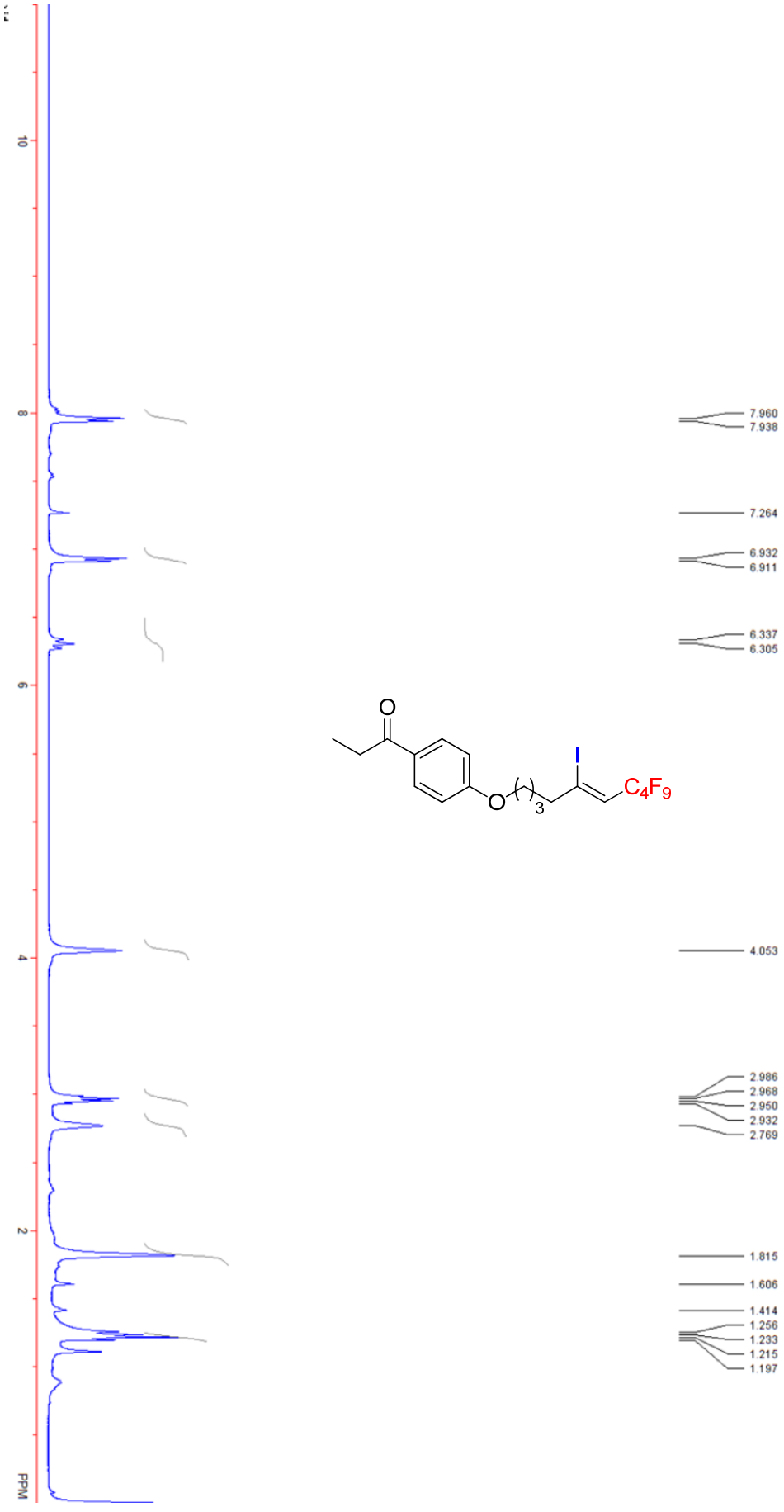
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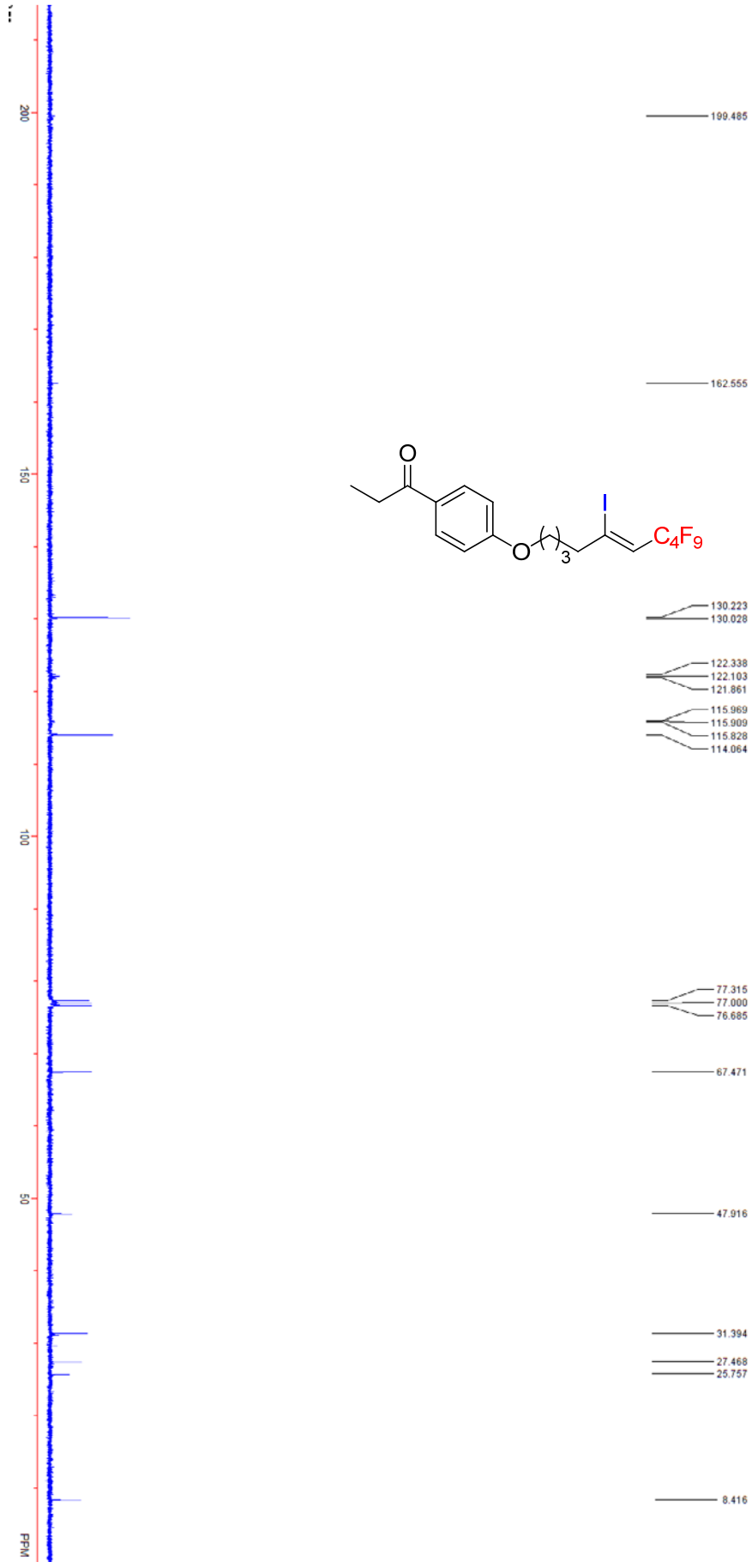
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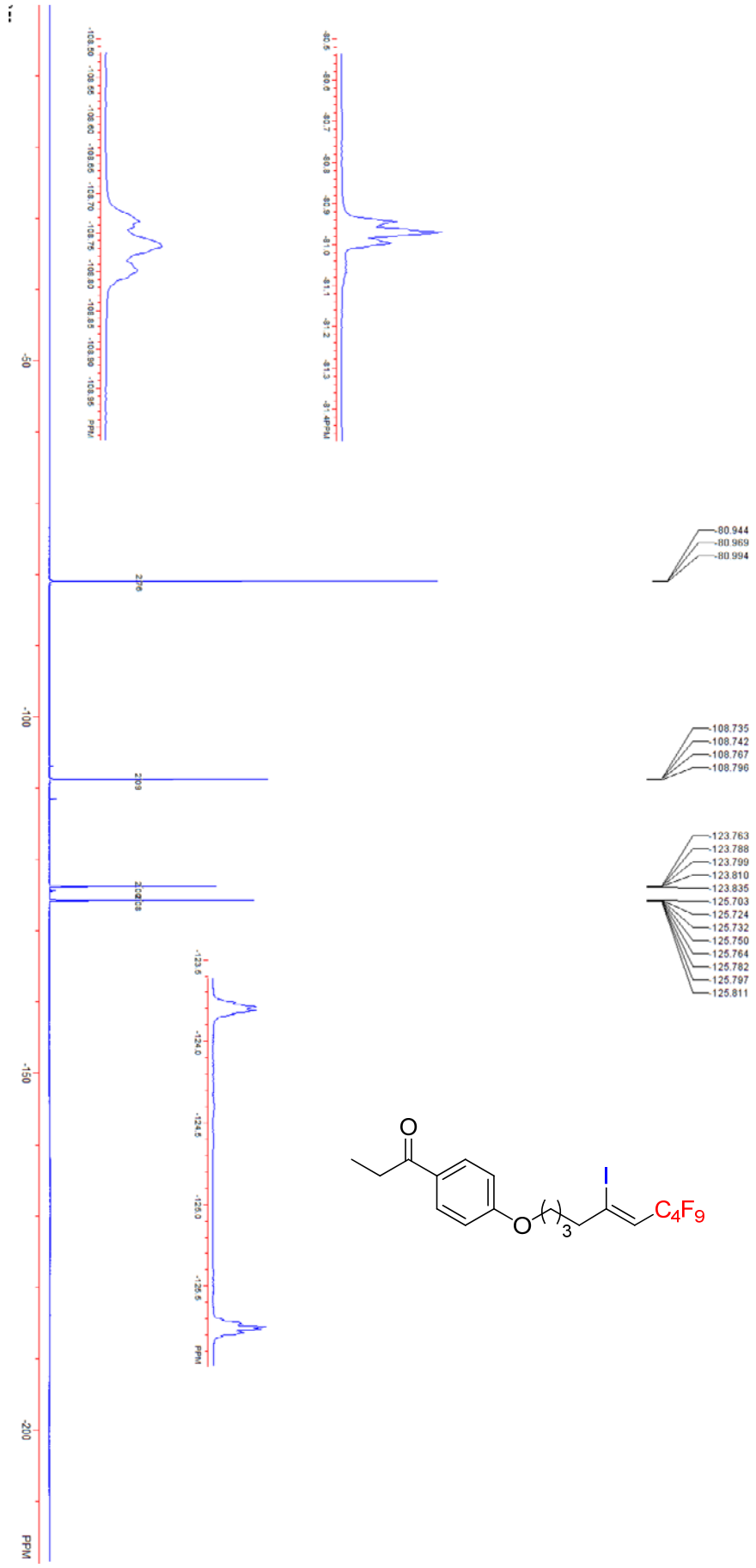
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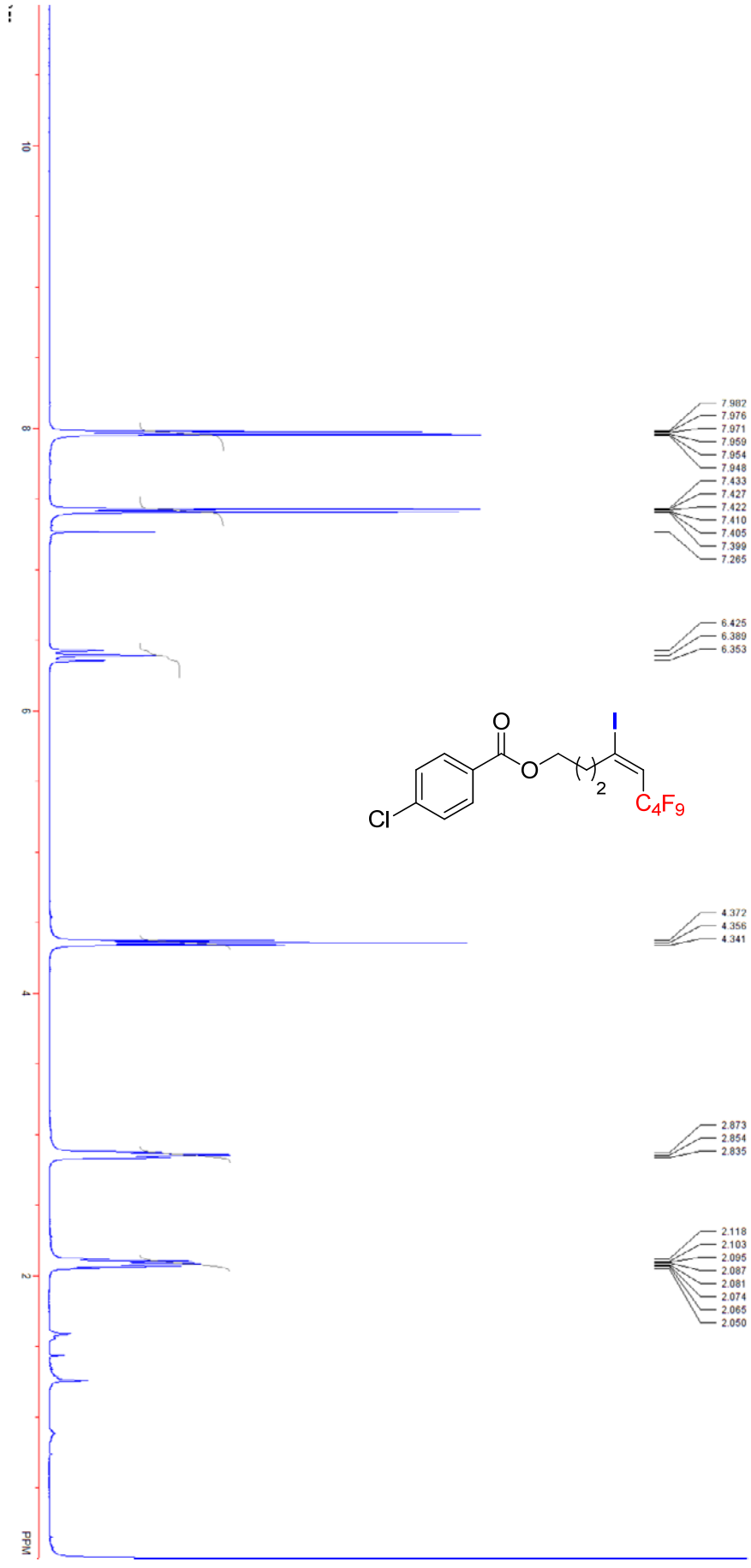
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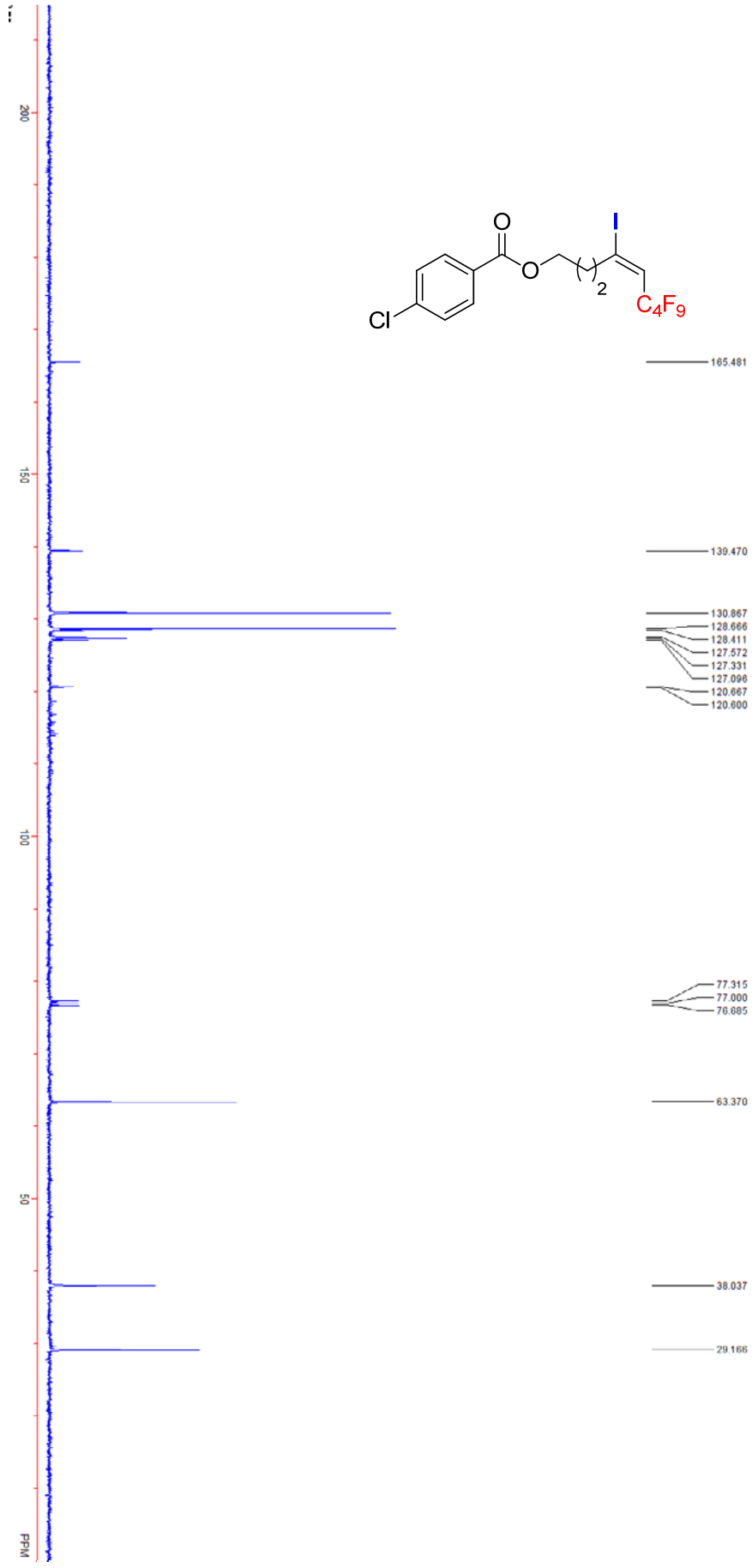
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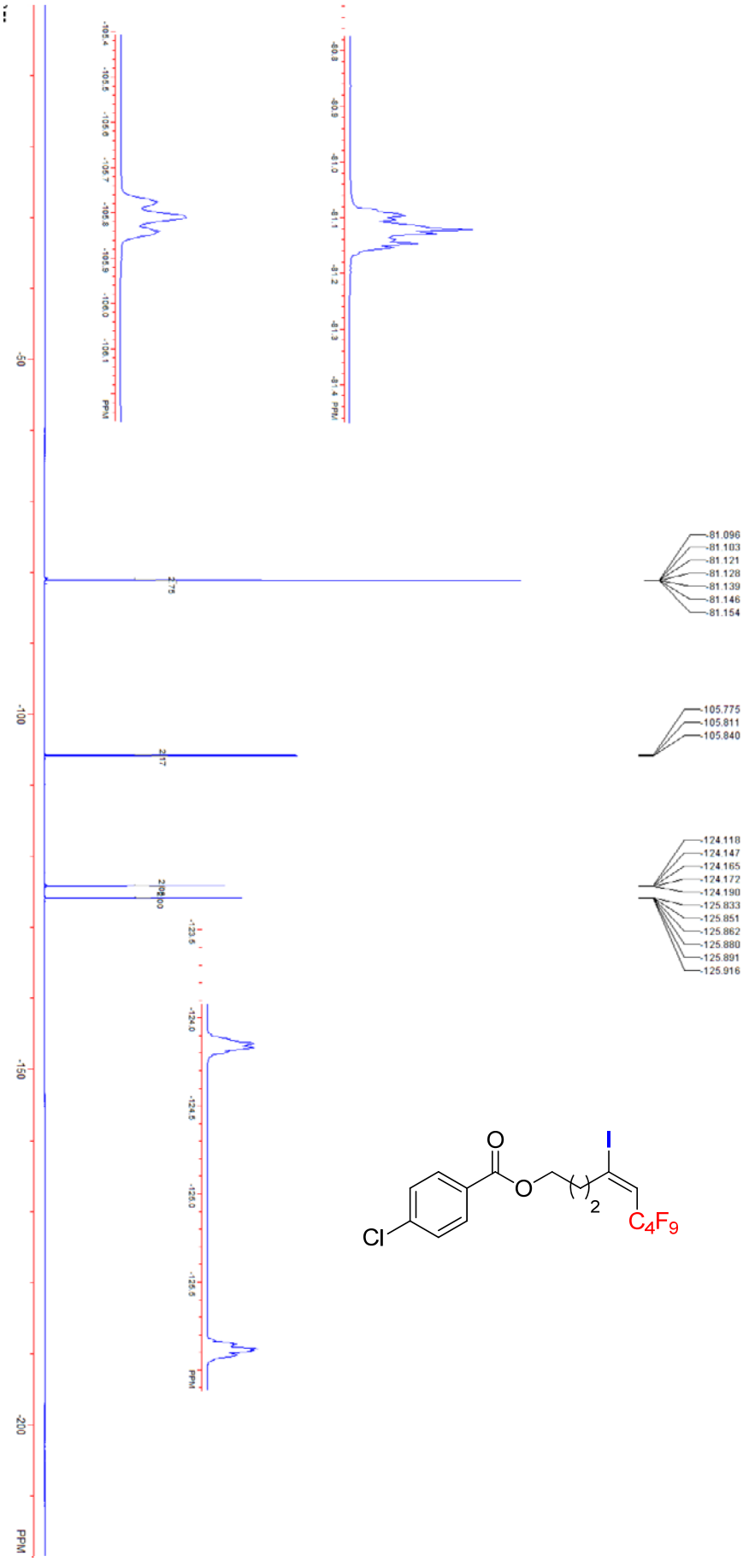
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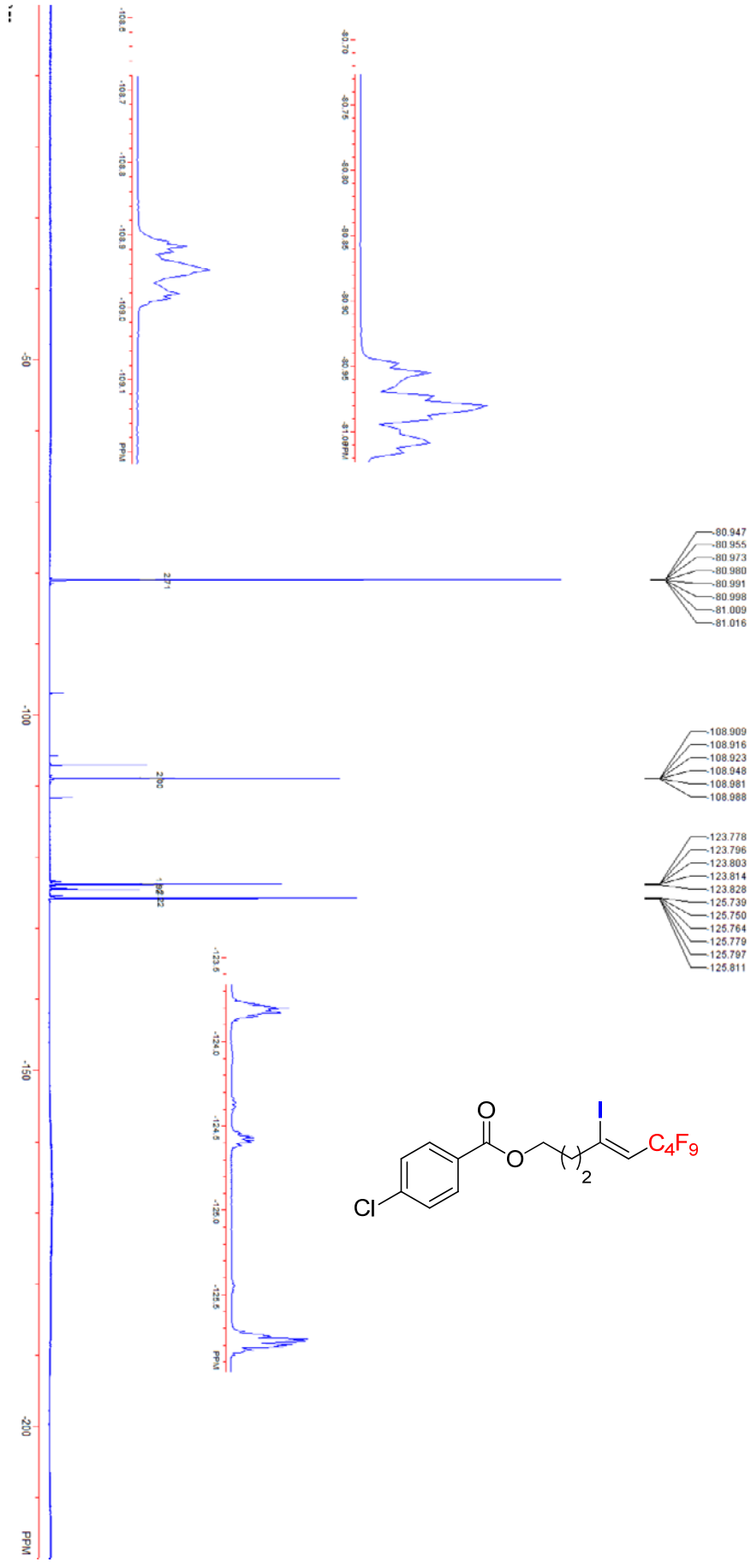
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C_4F_9
2
Cl


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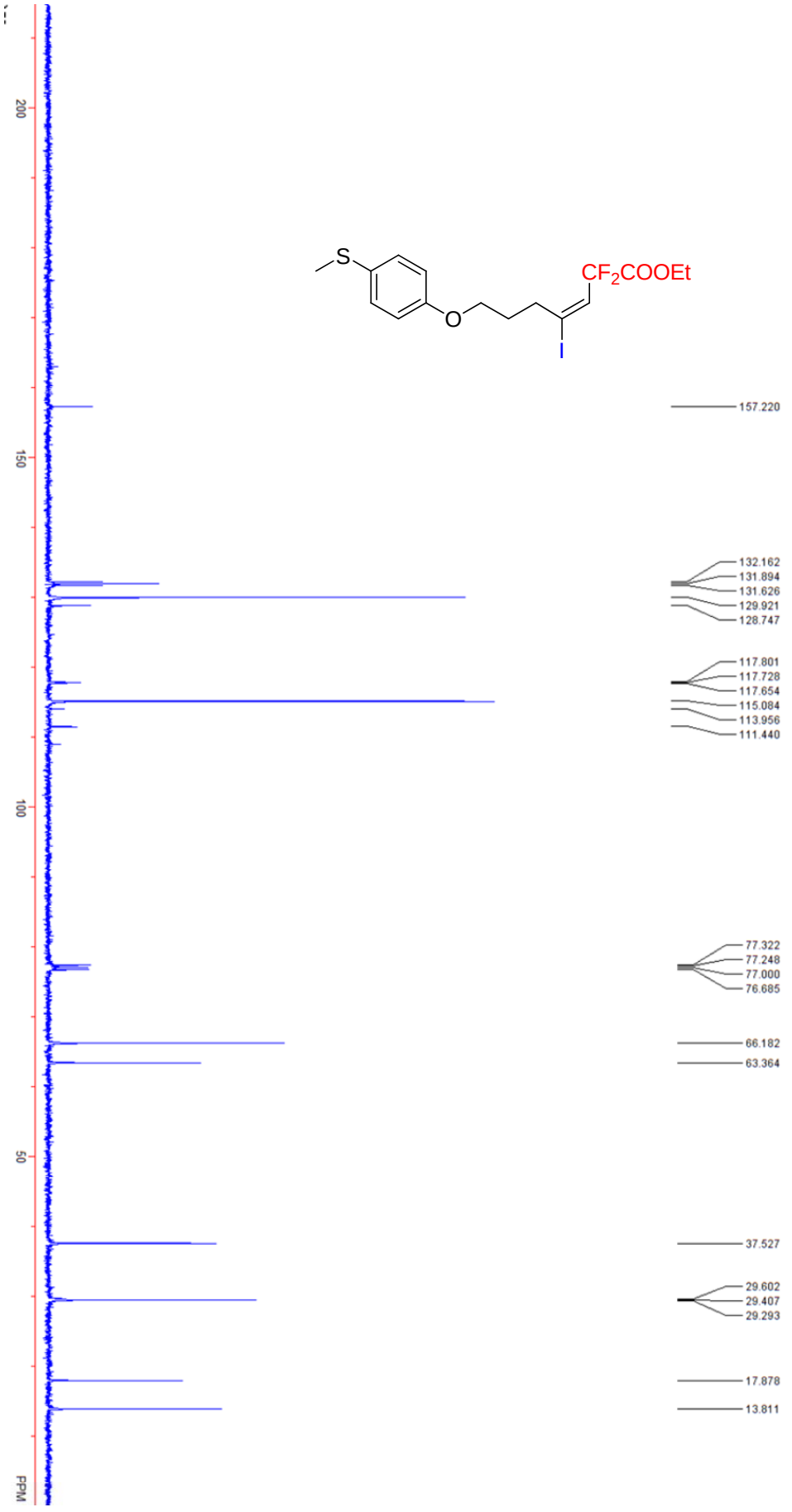
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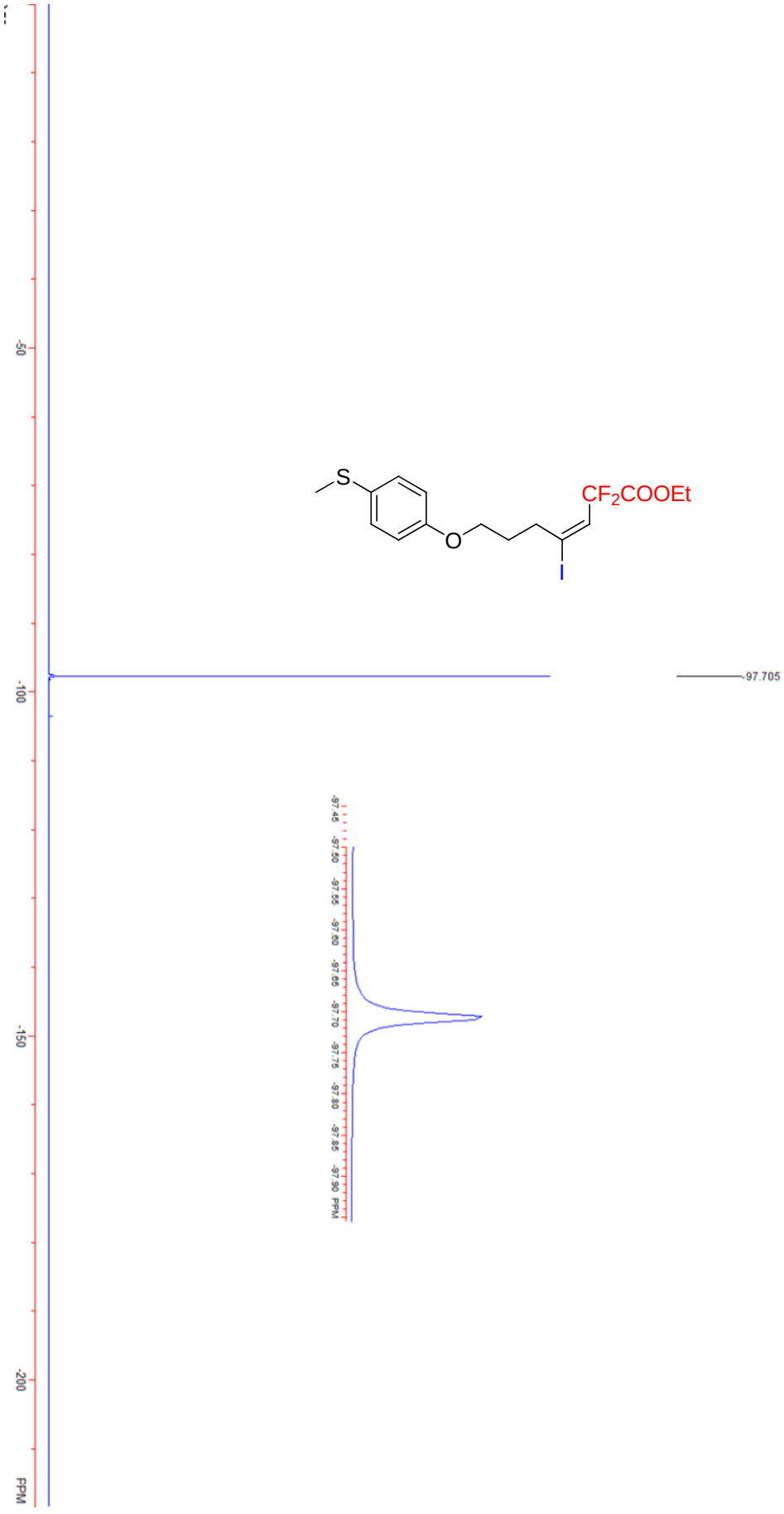
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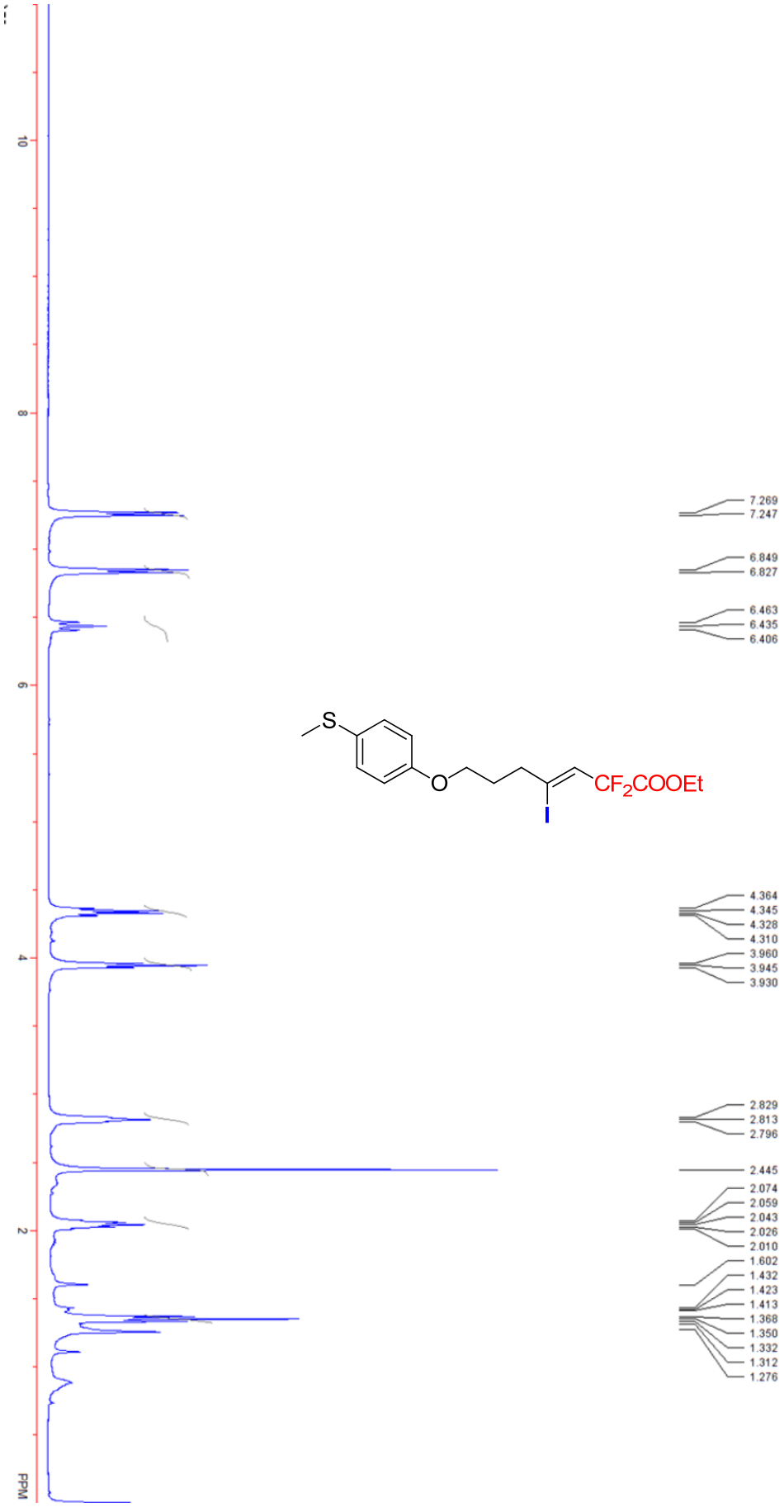
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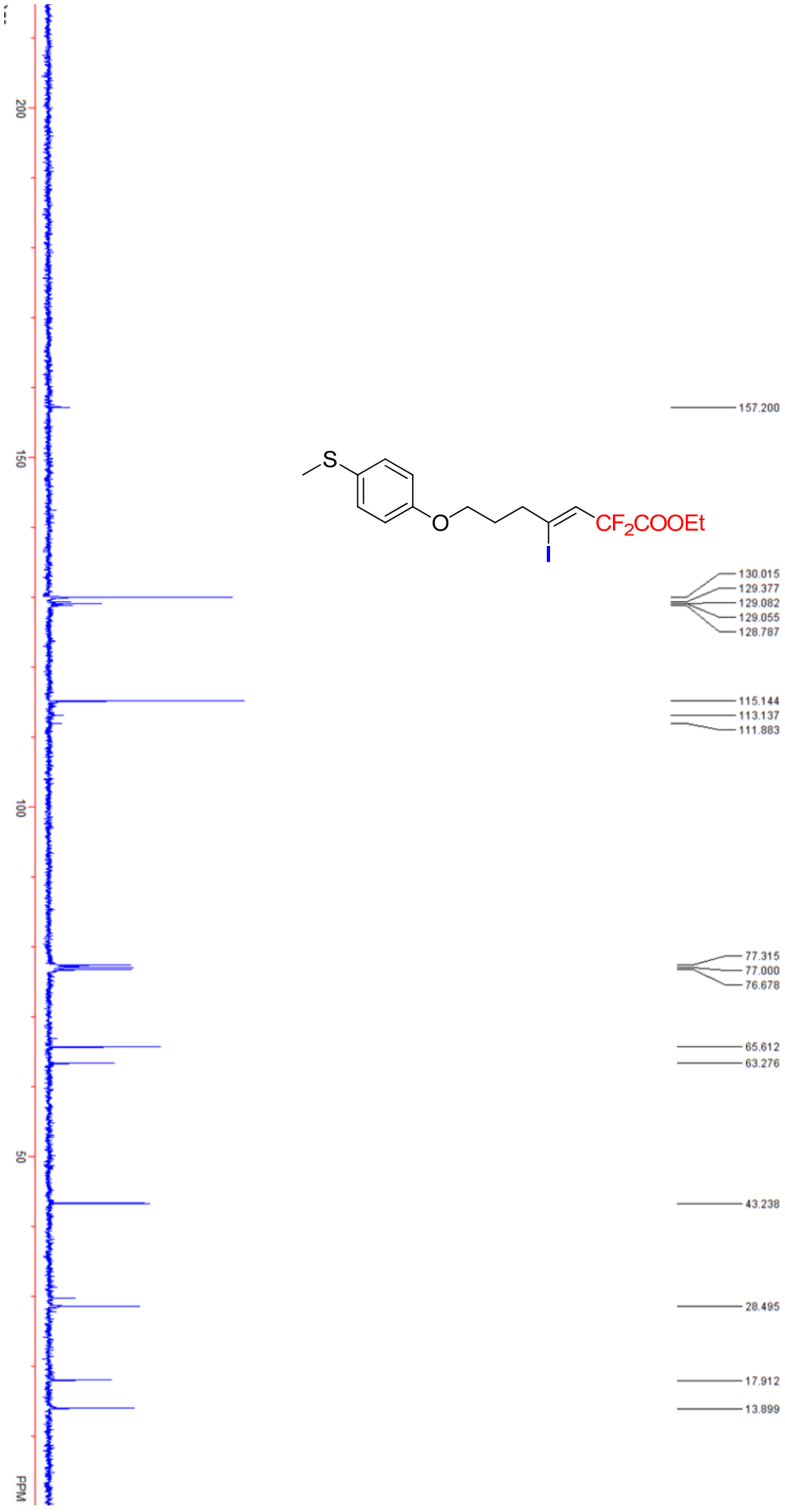
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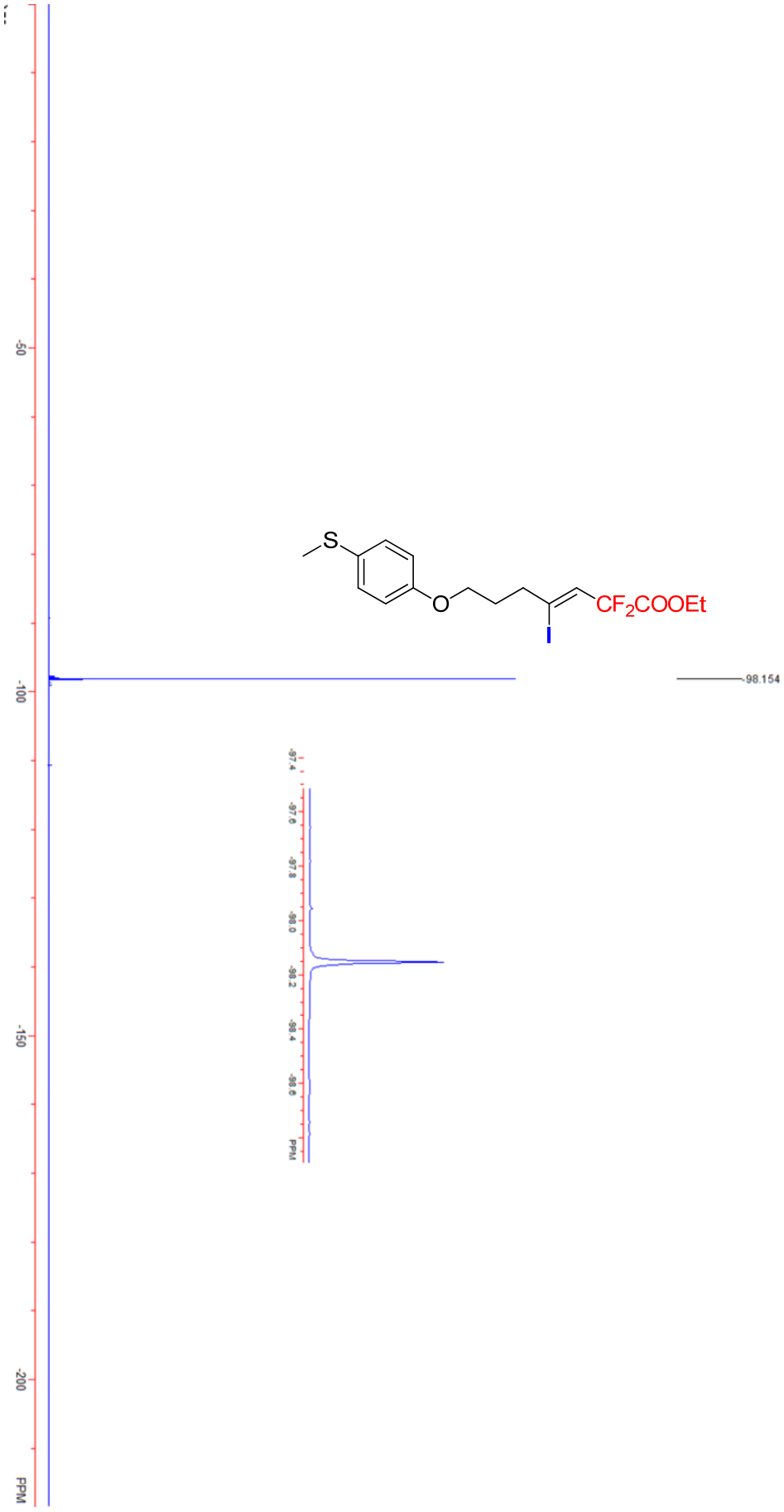
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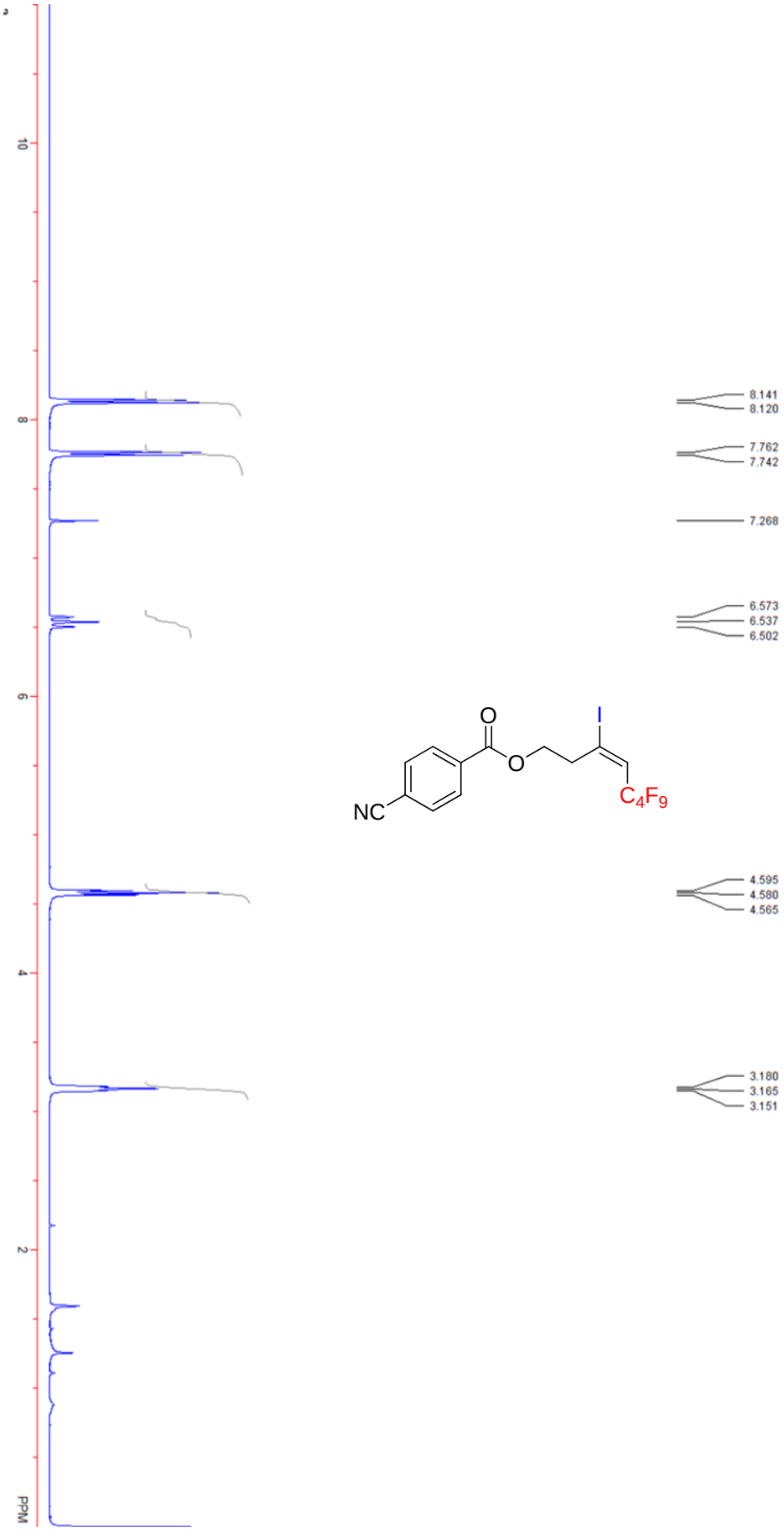
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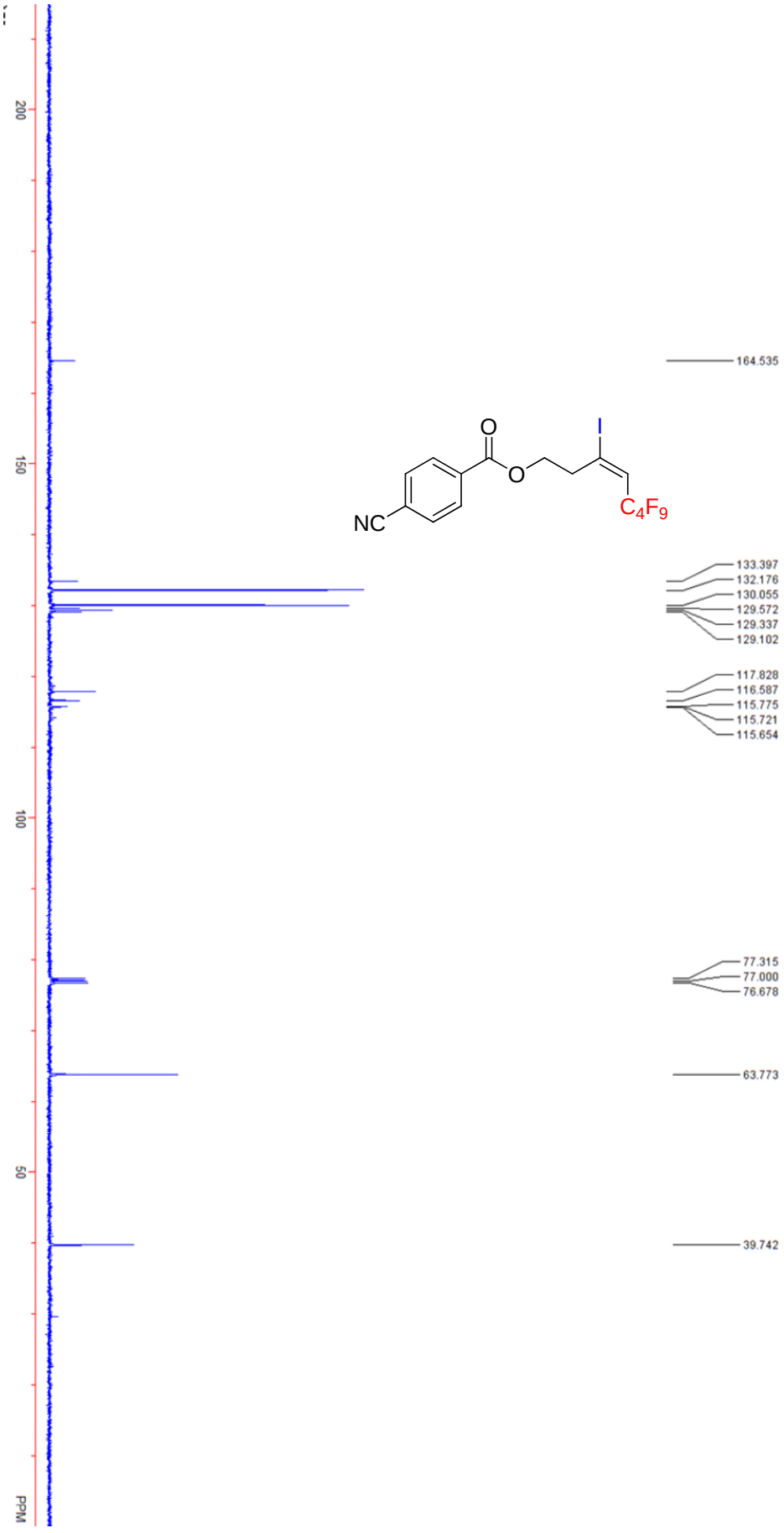
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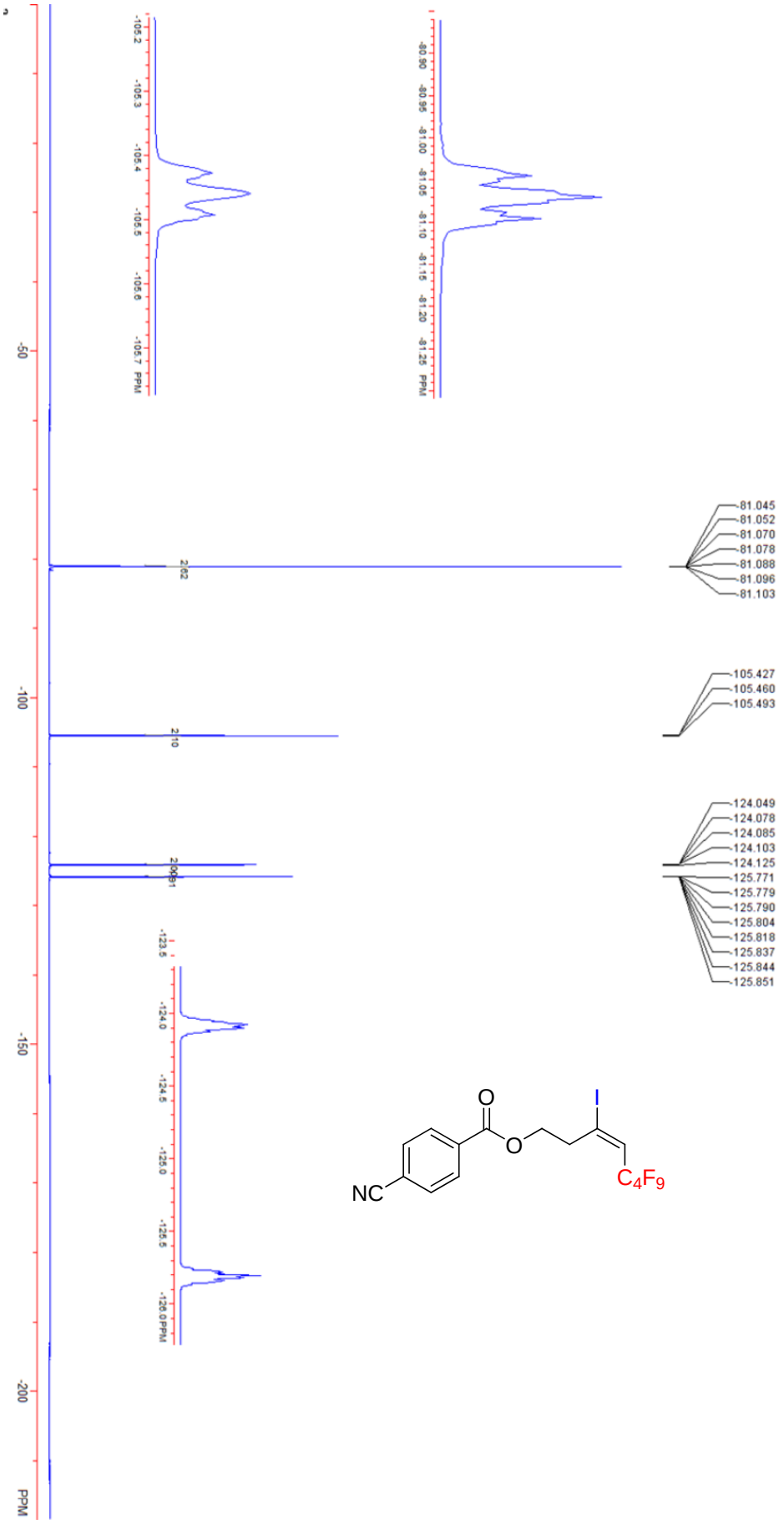
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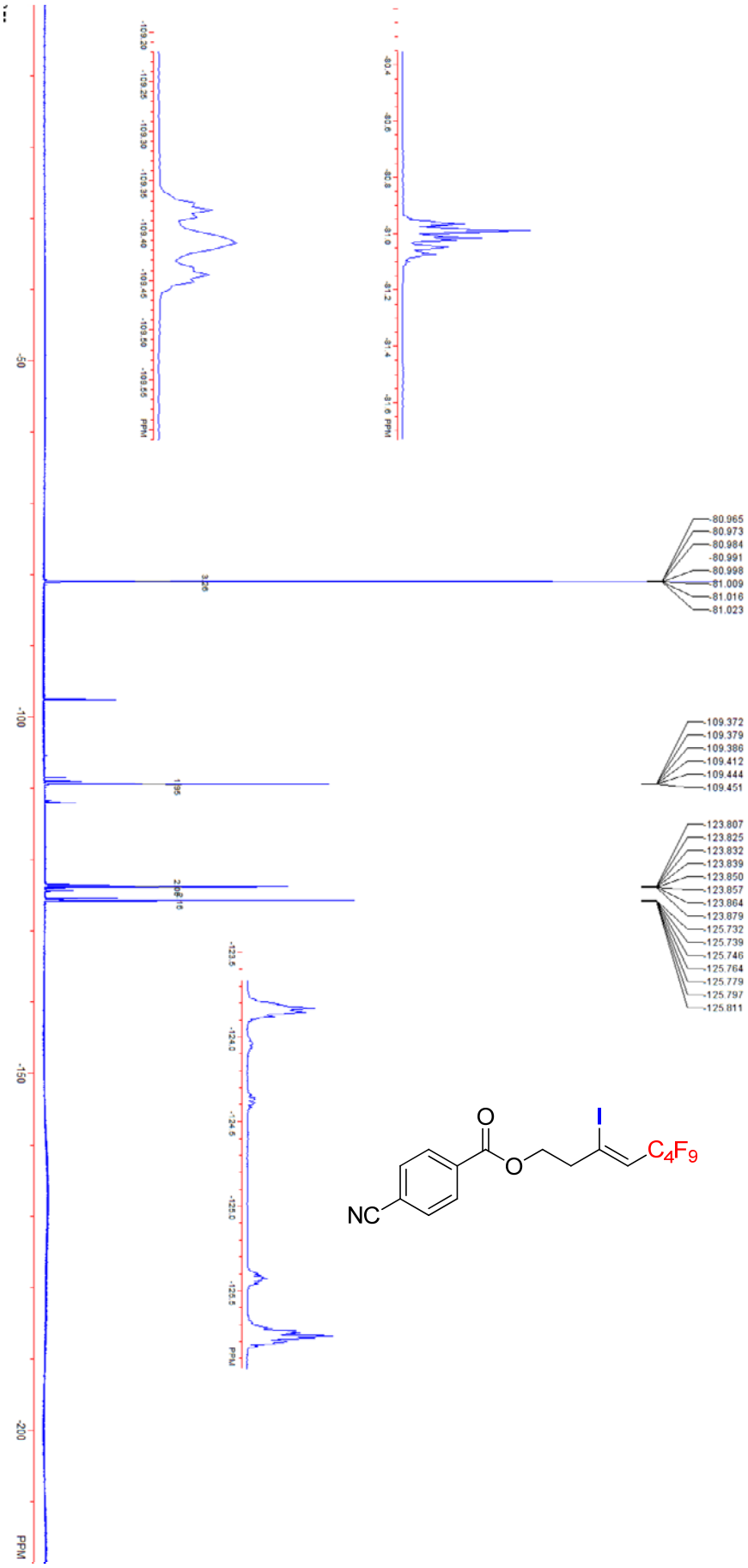
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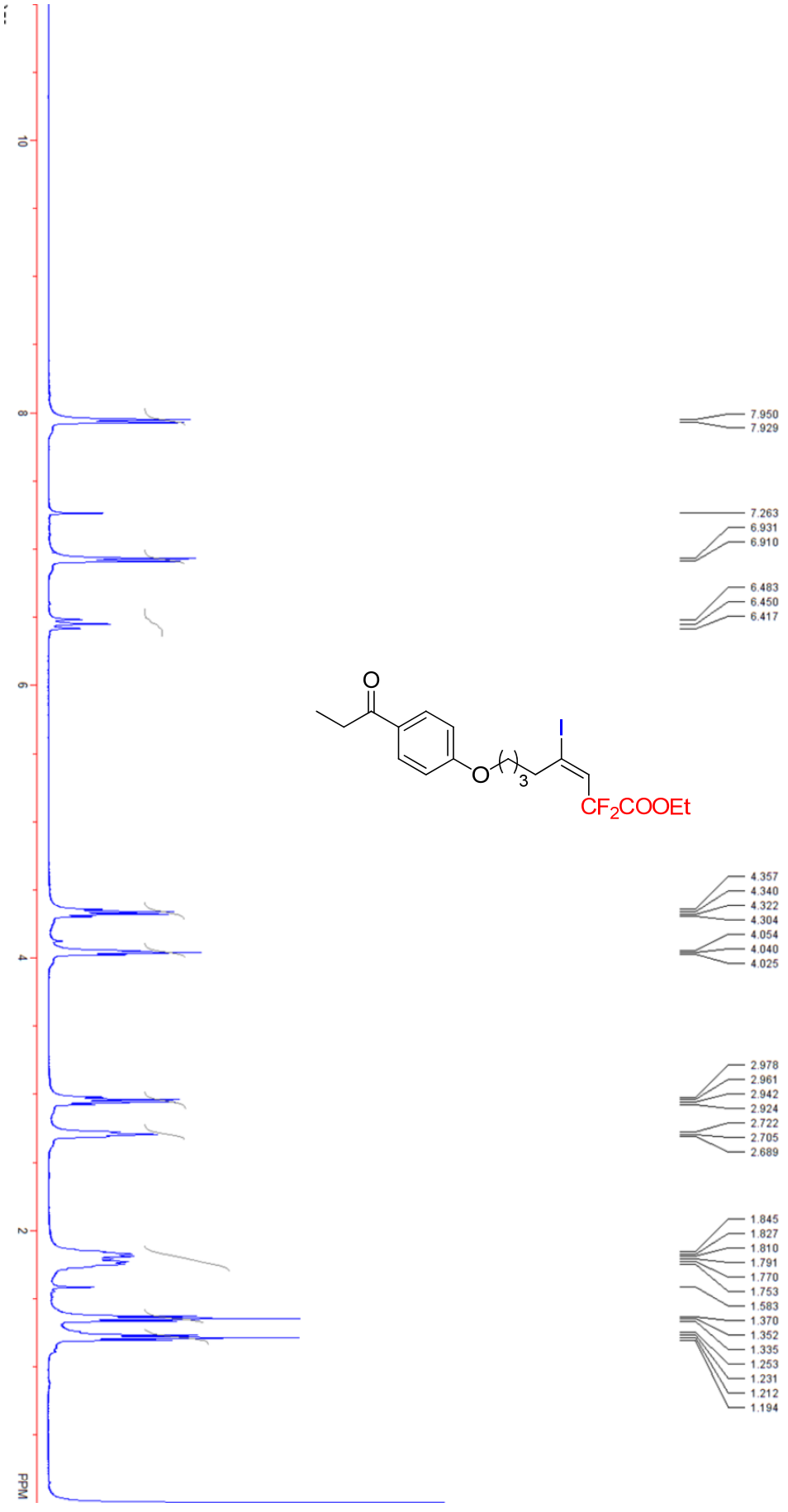
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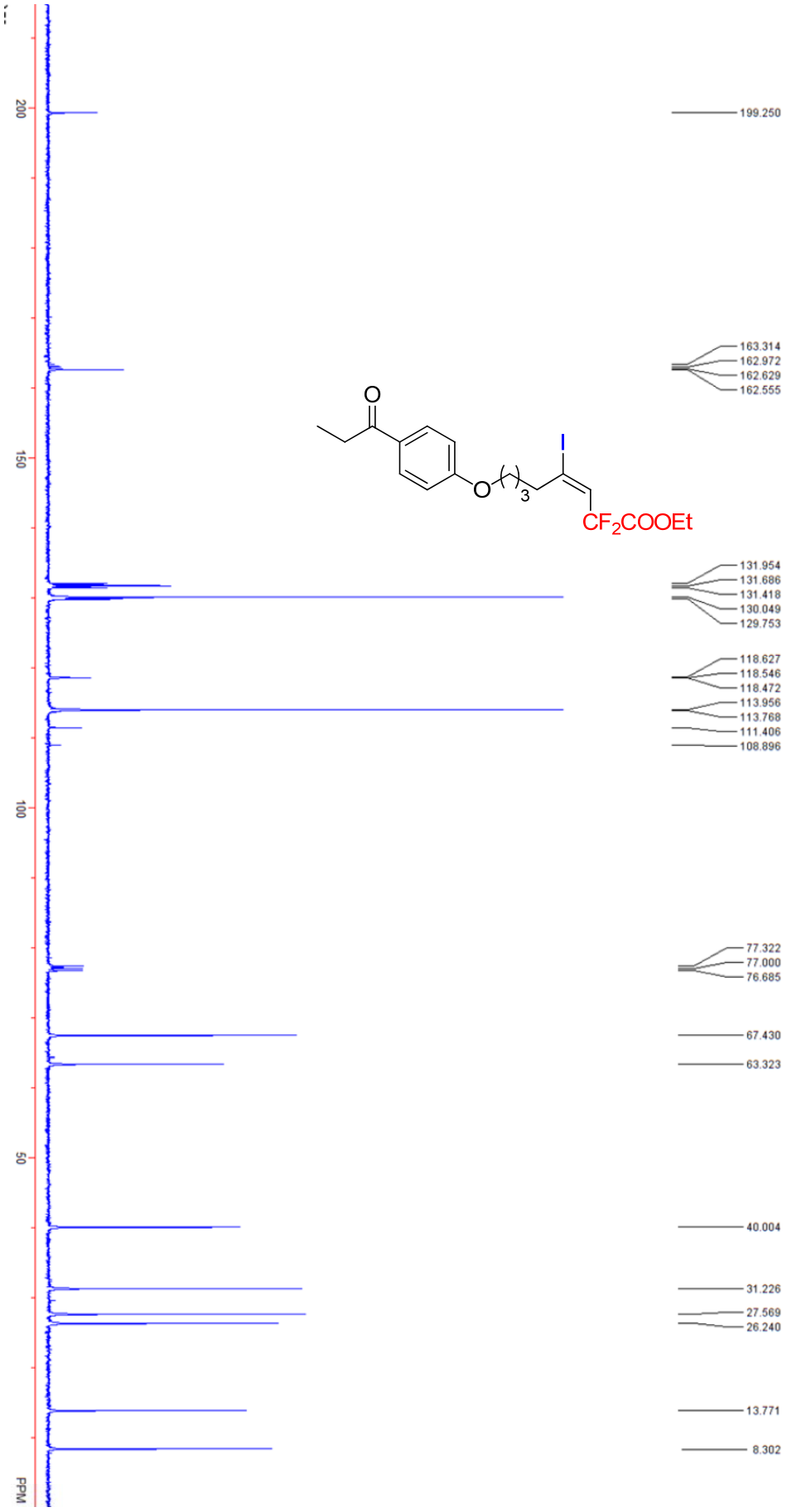
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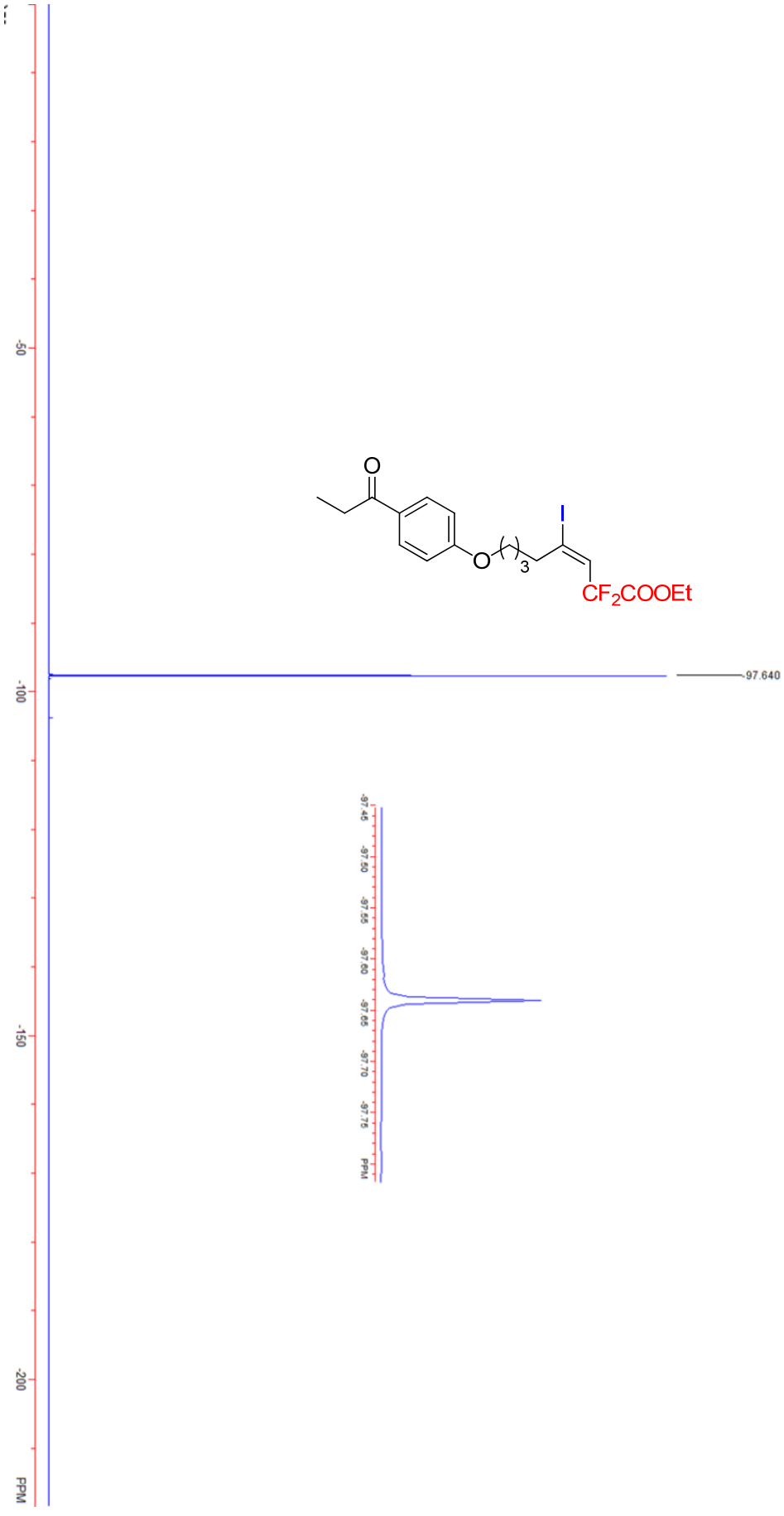
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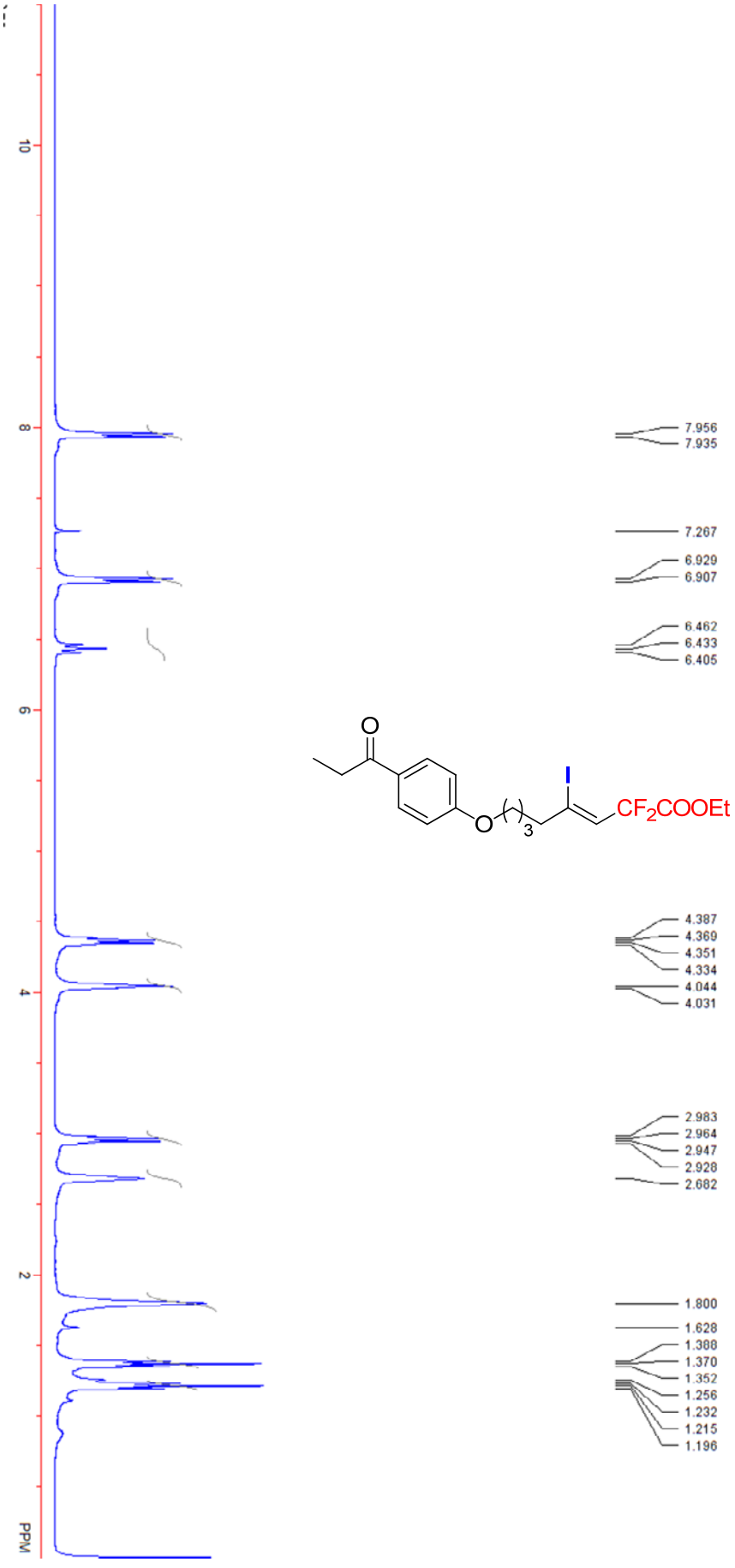
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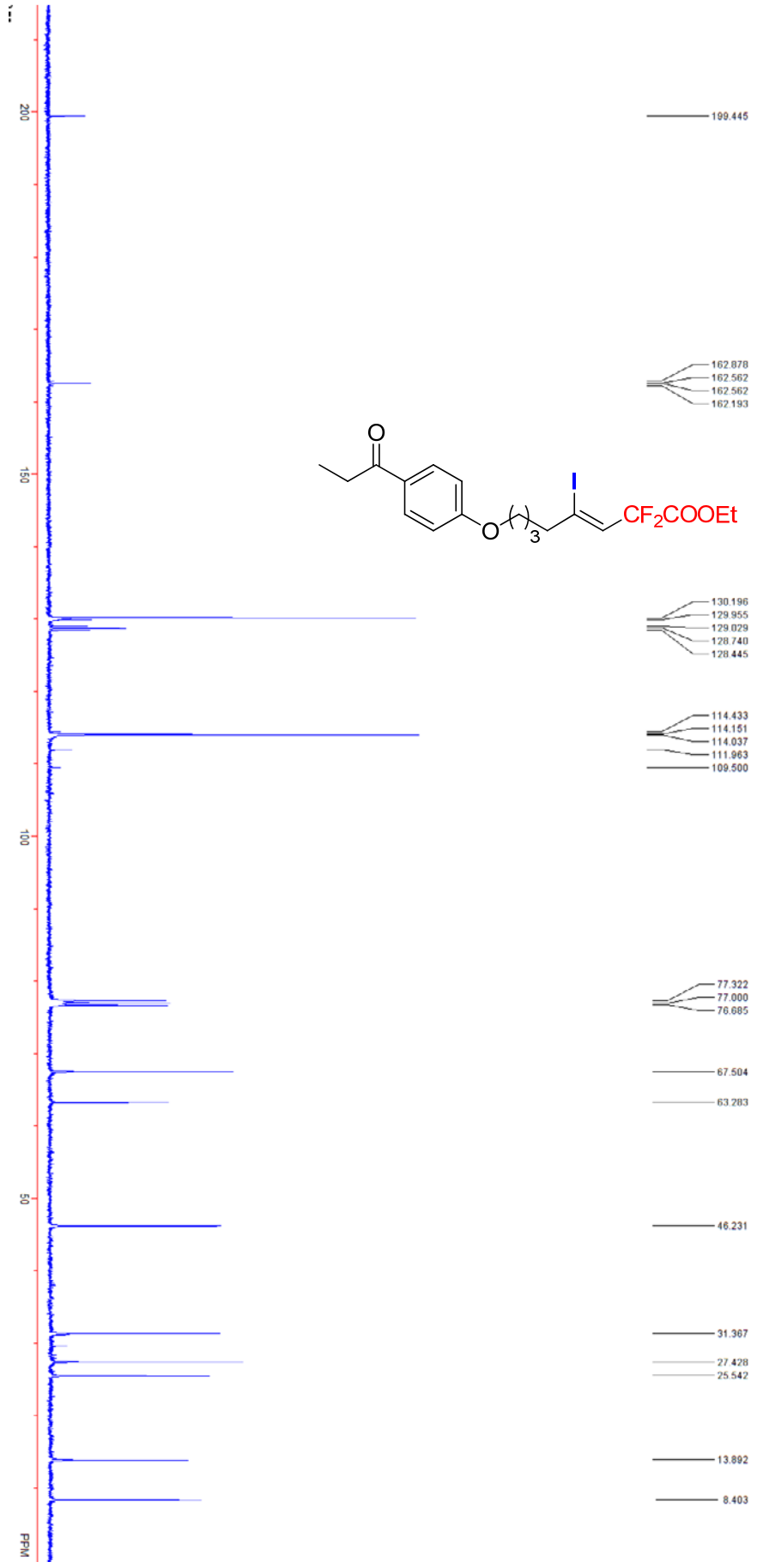
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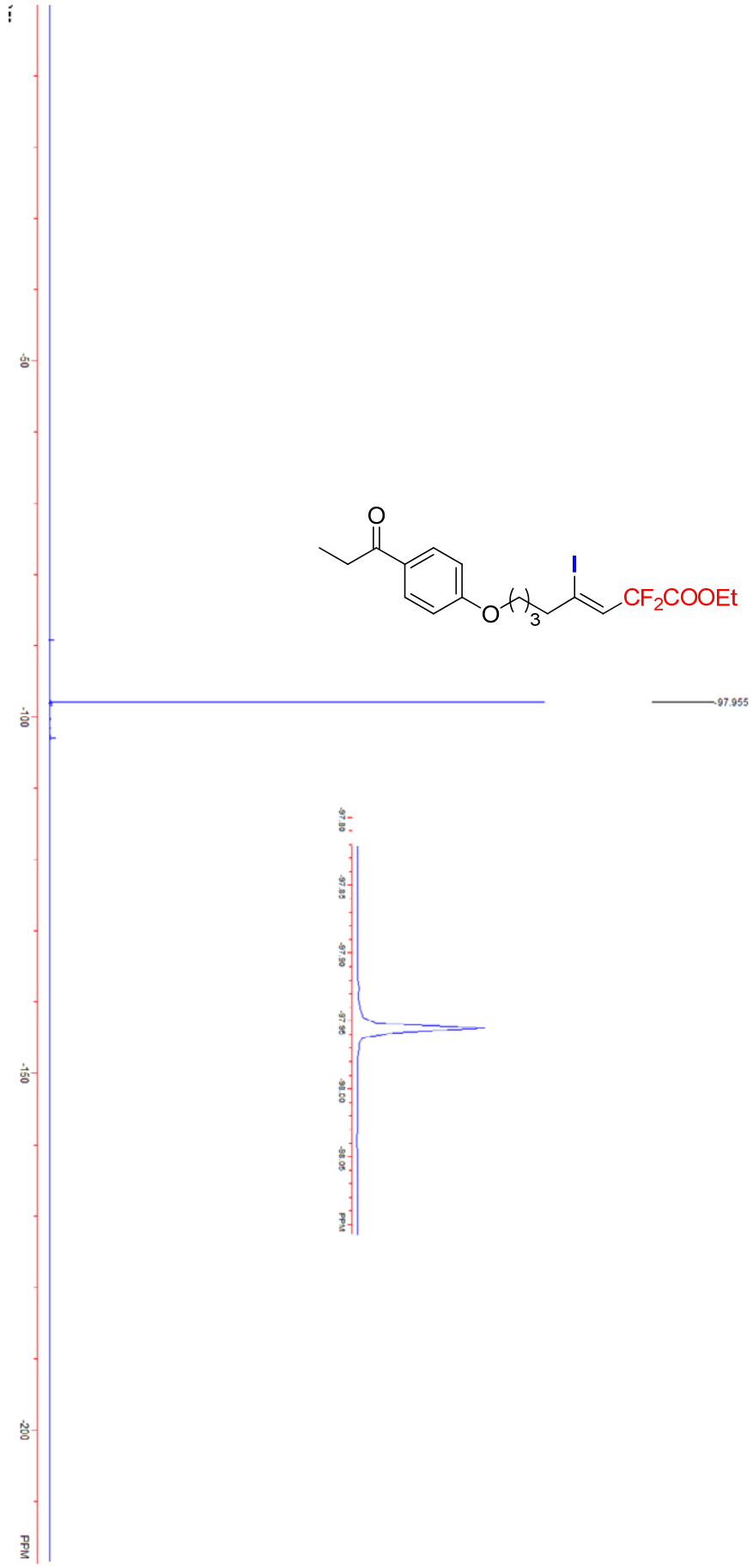
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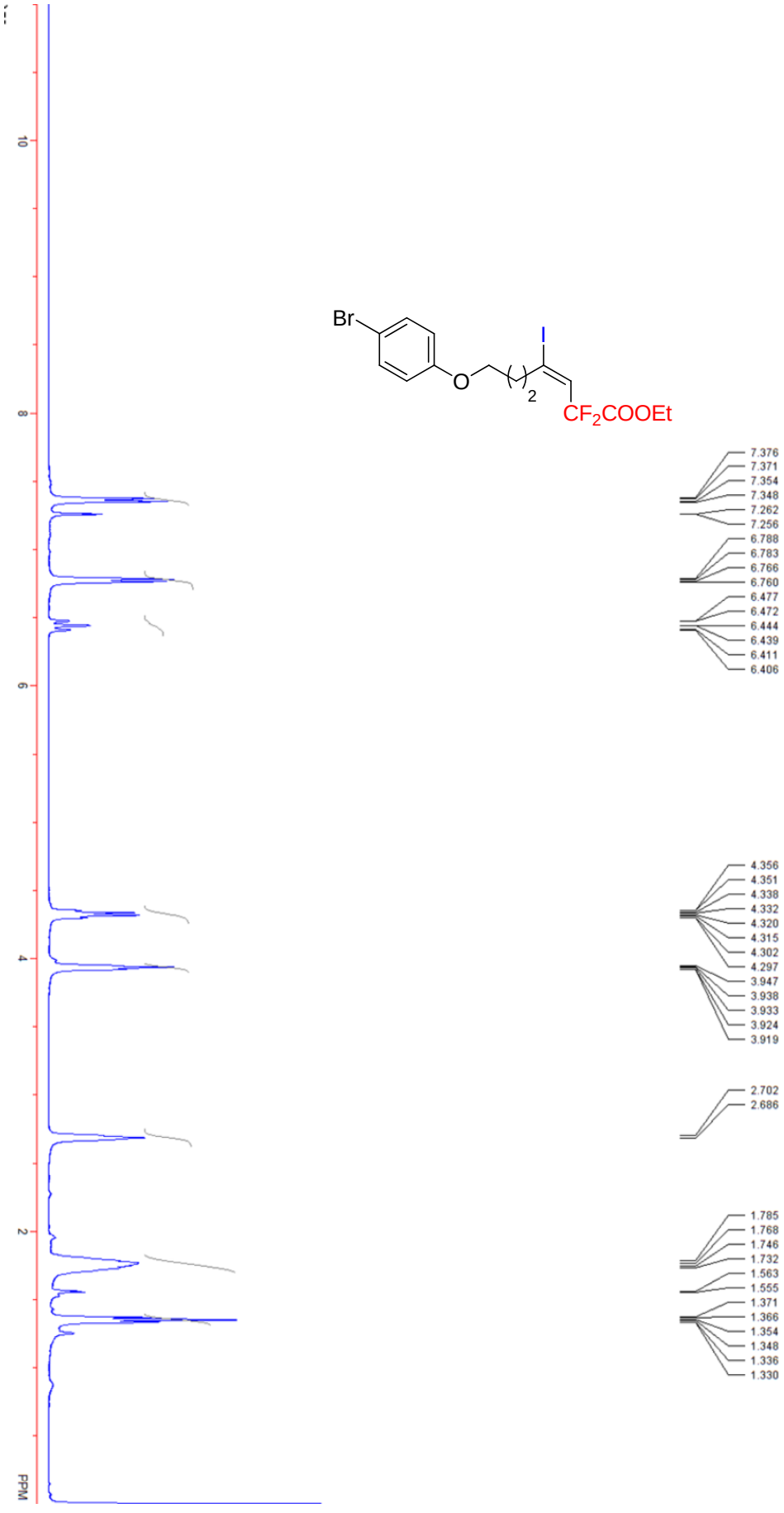
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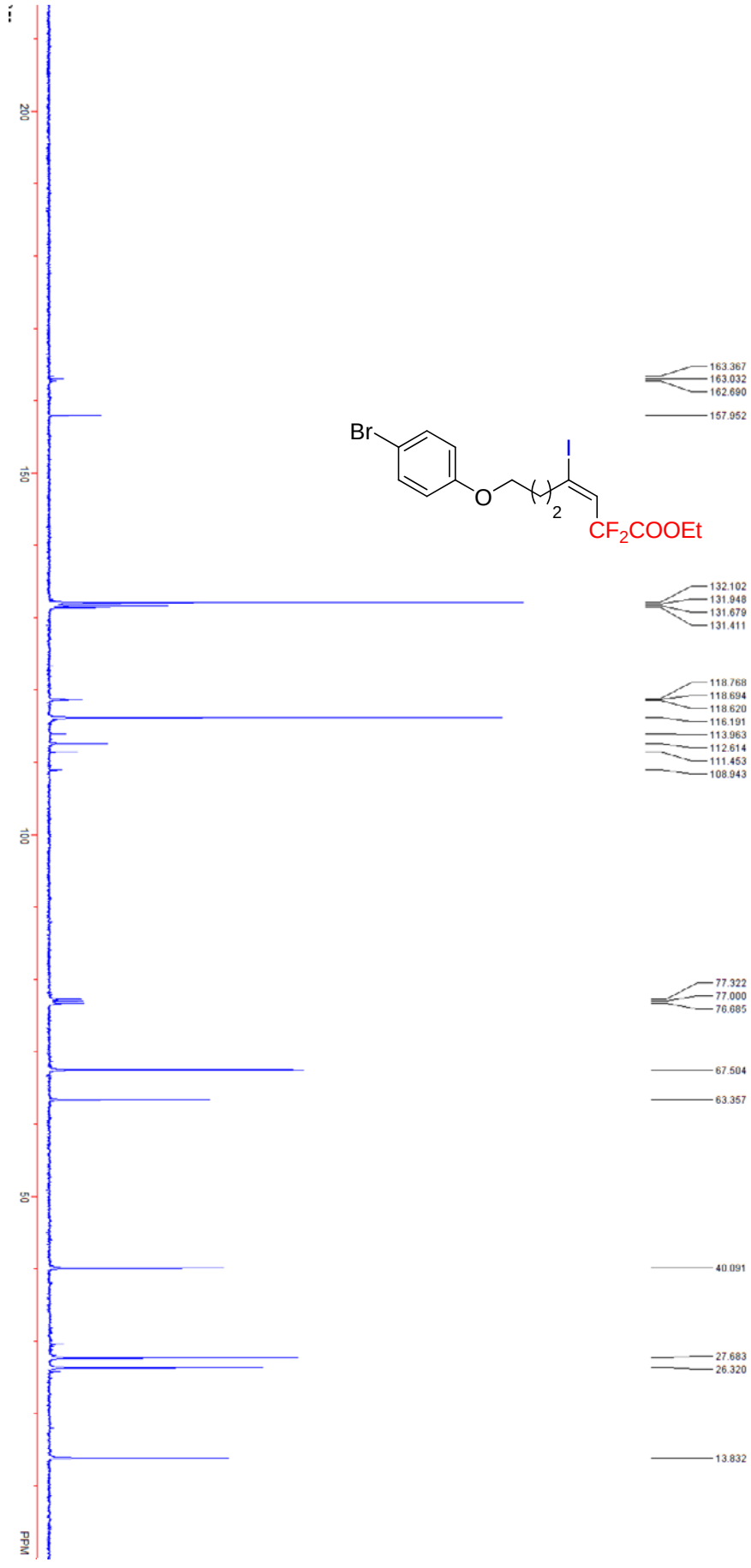
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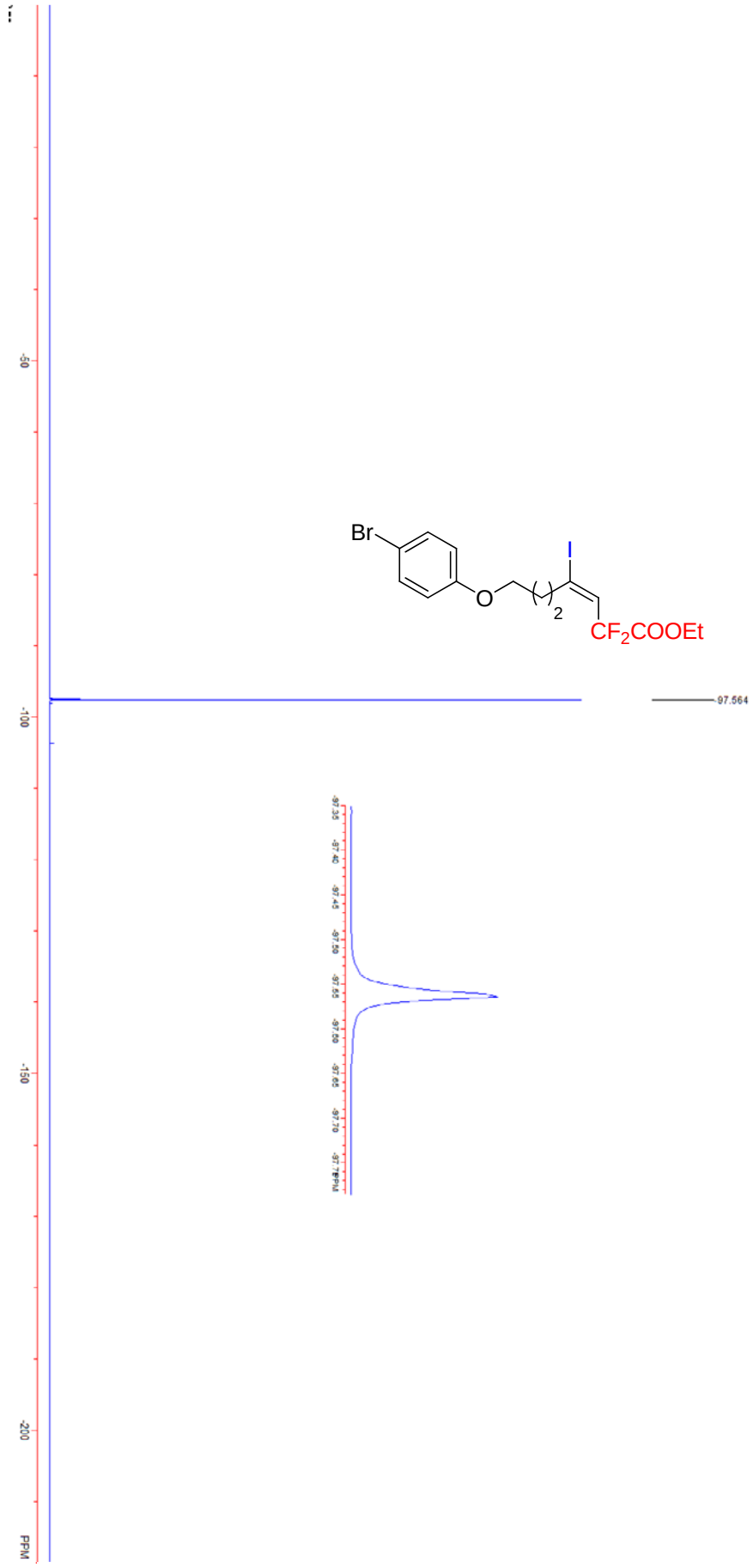
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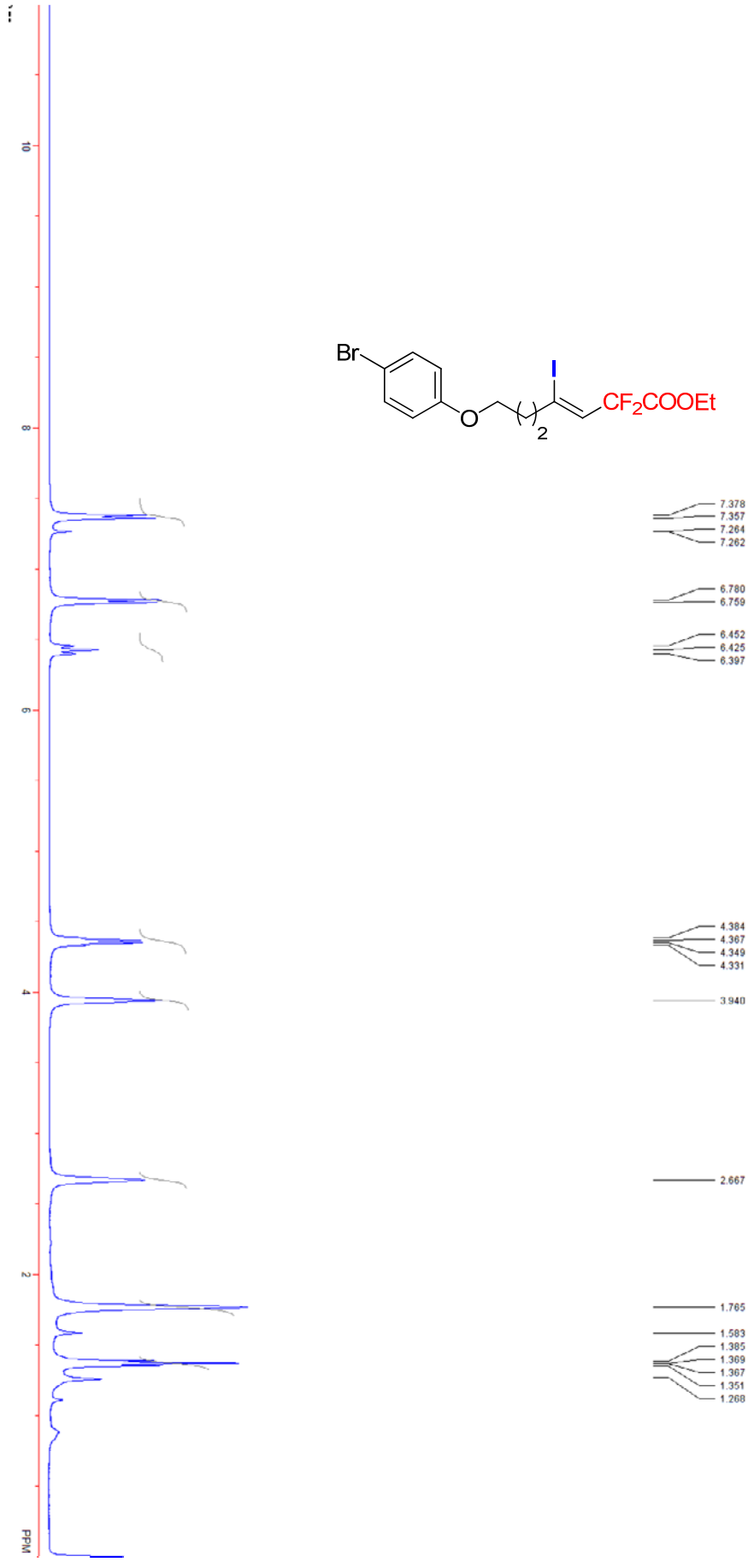
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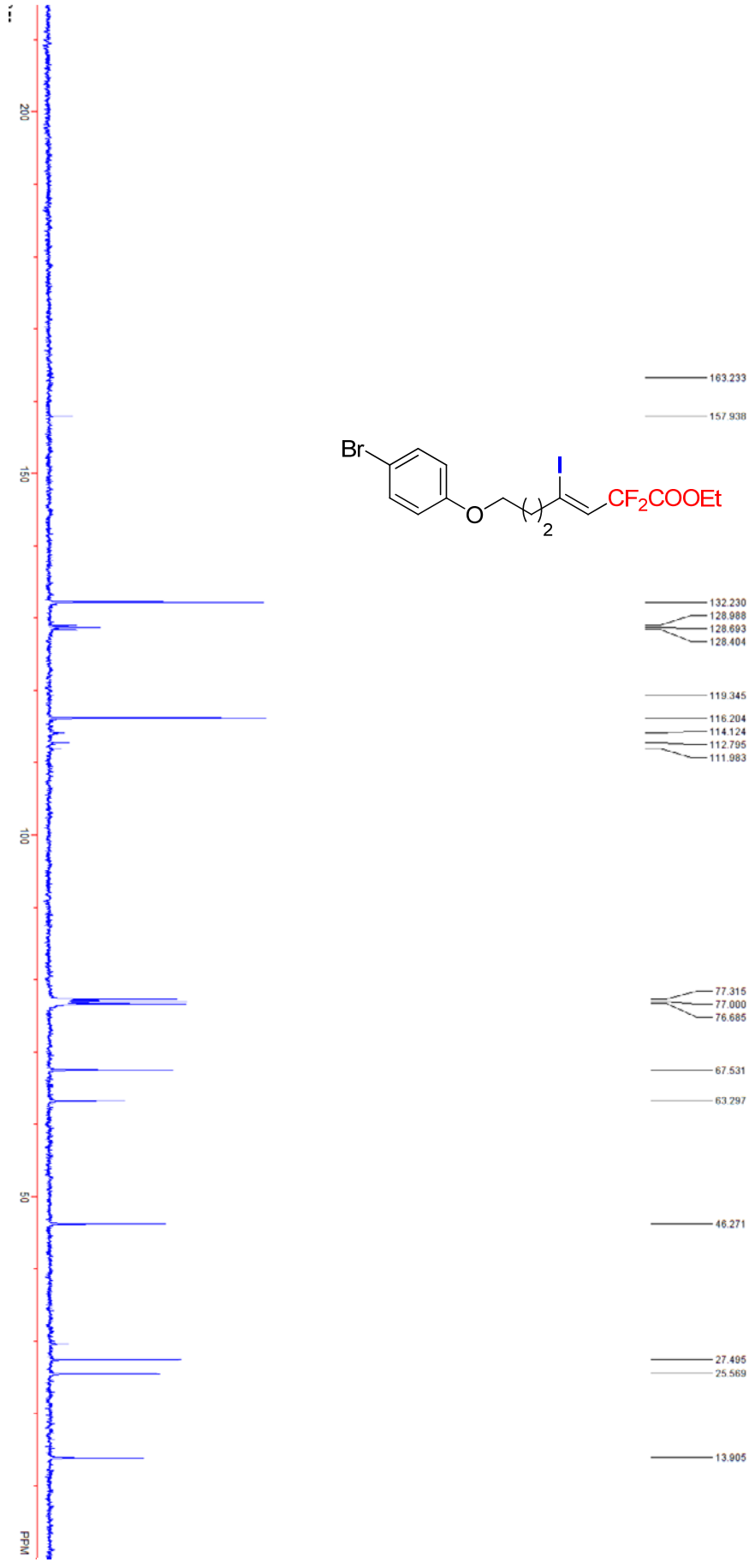
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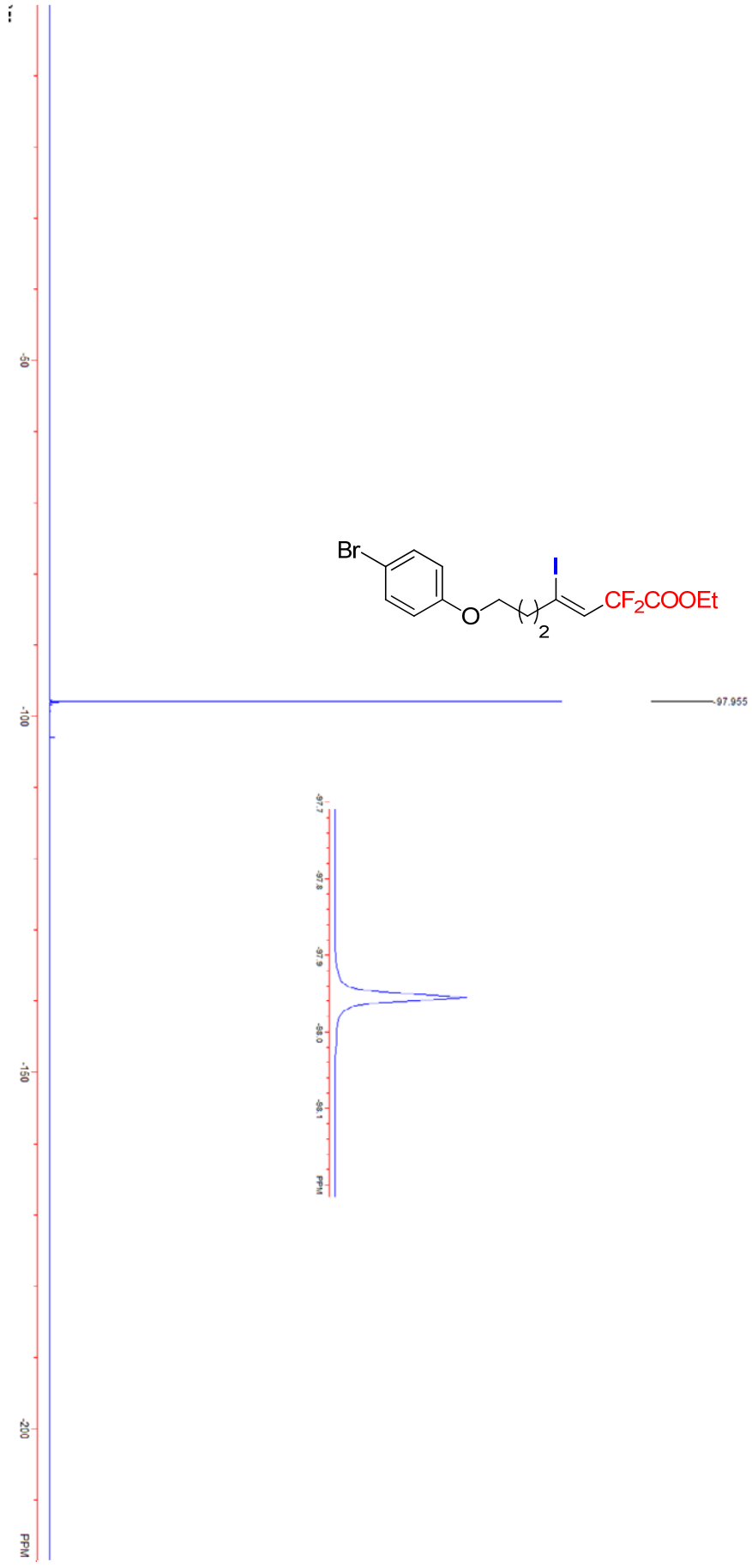
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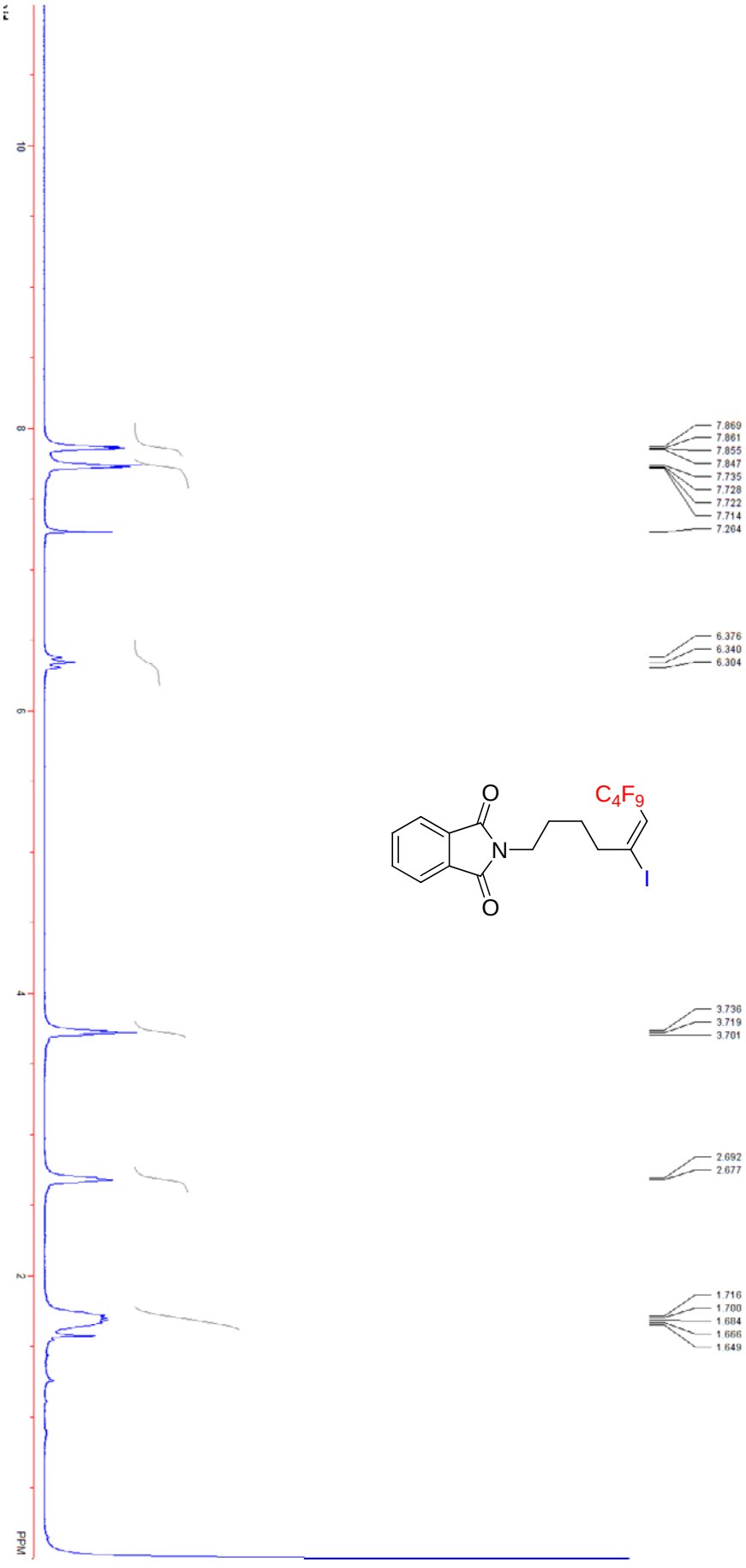
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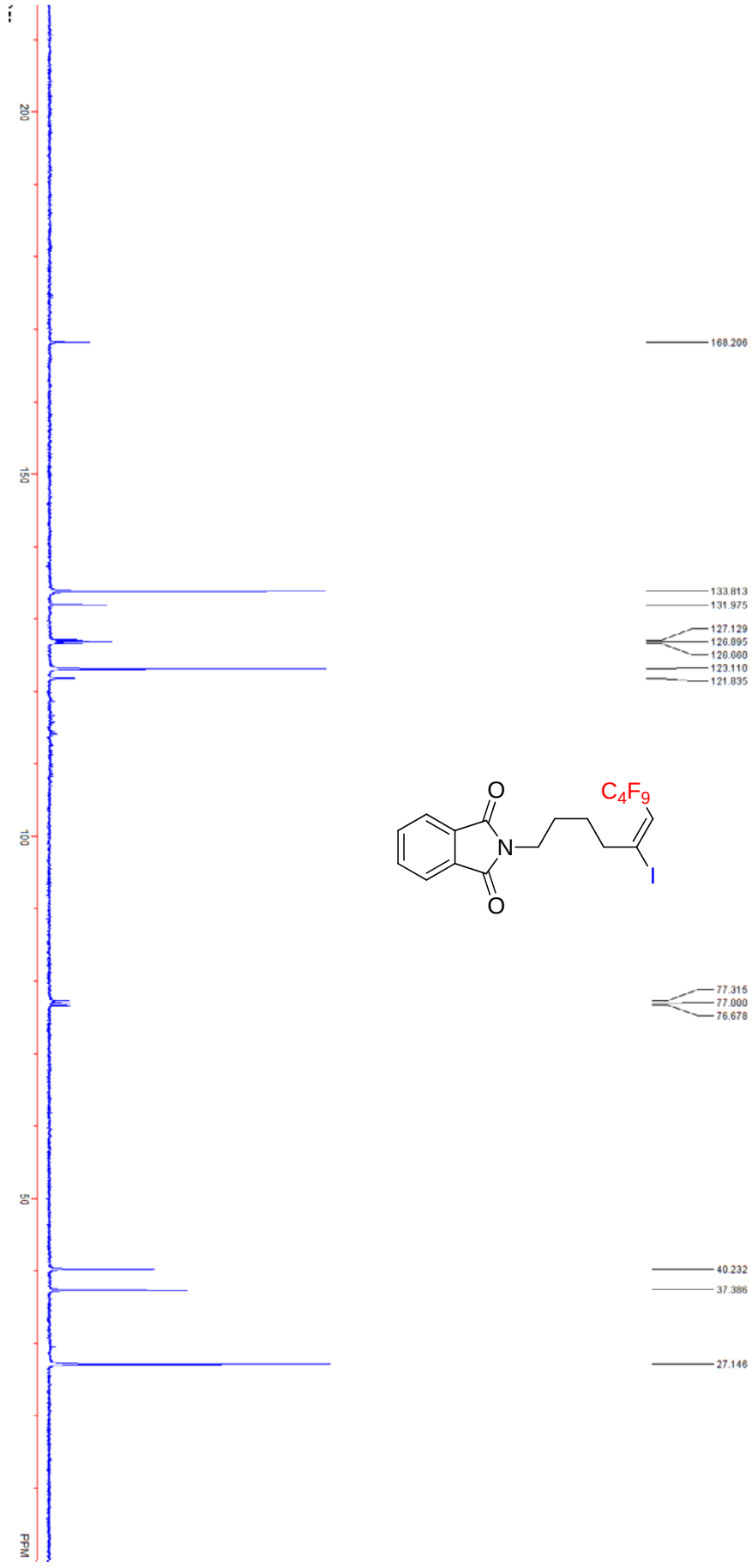
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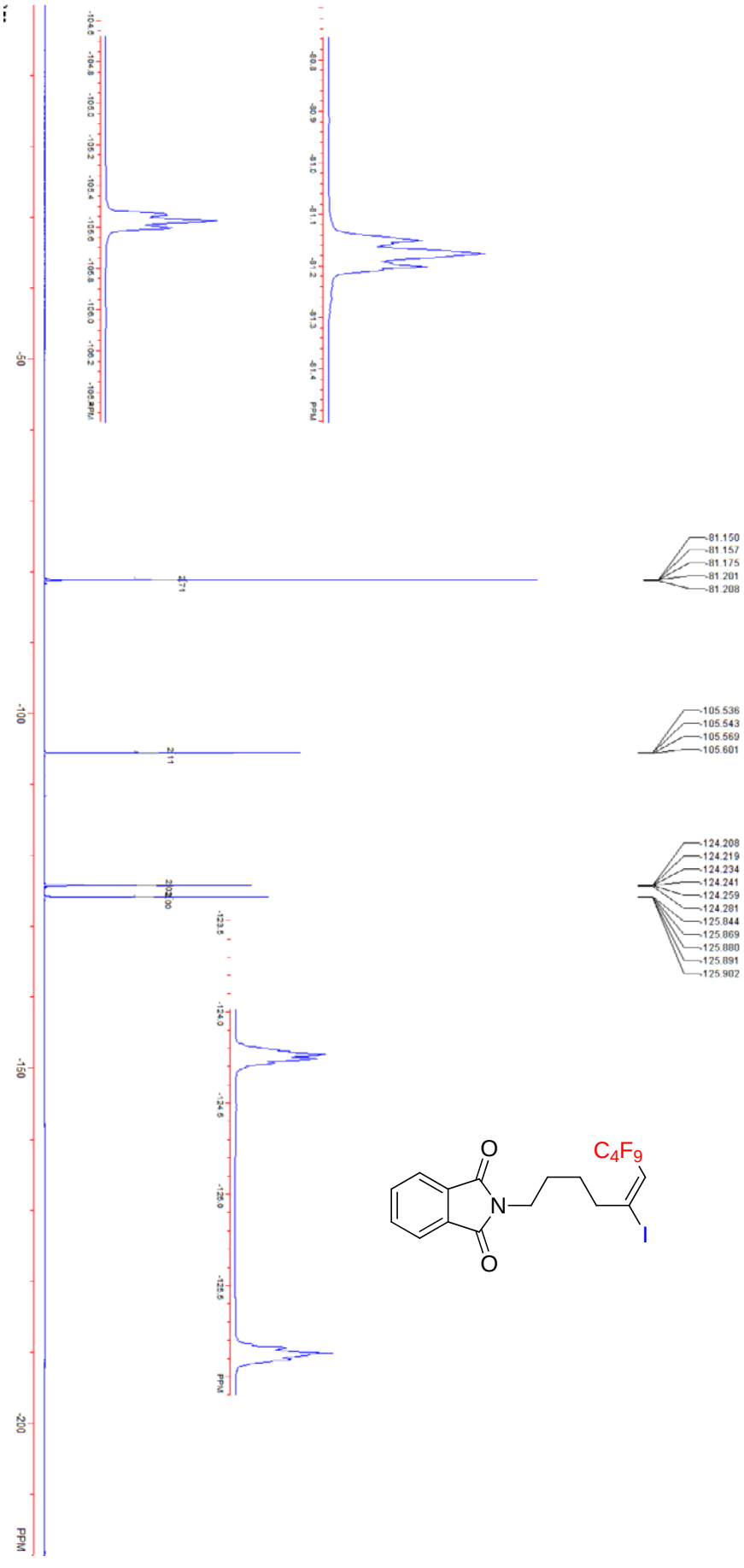
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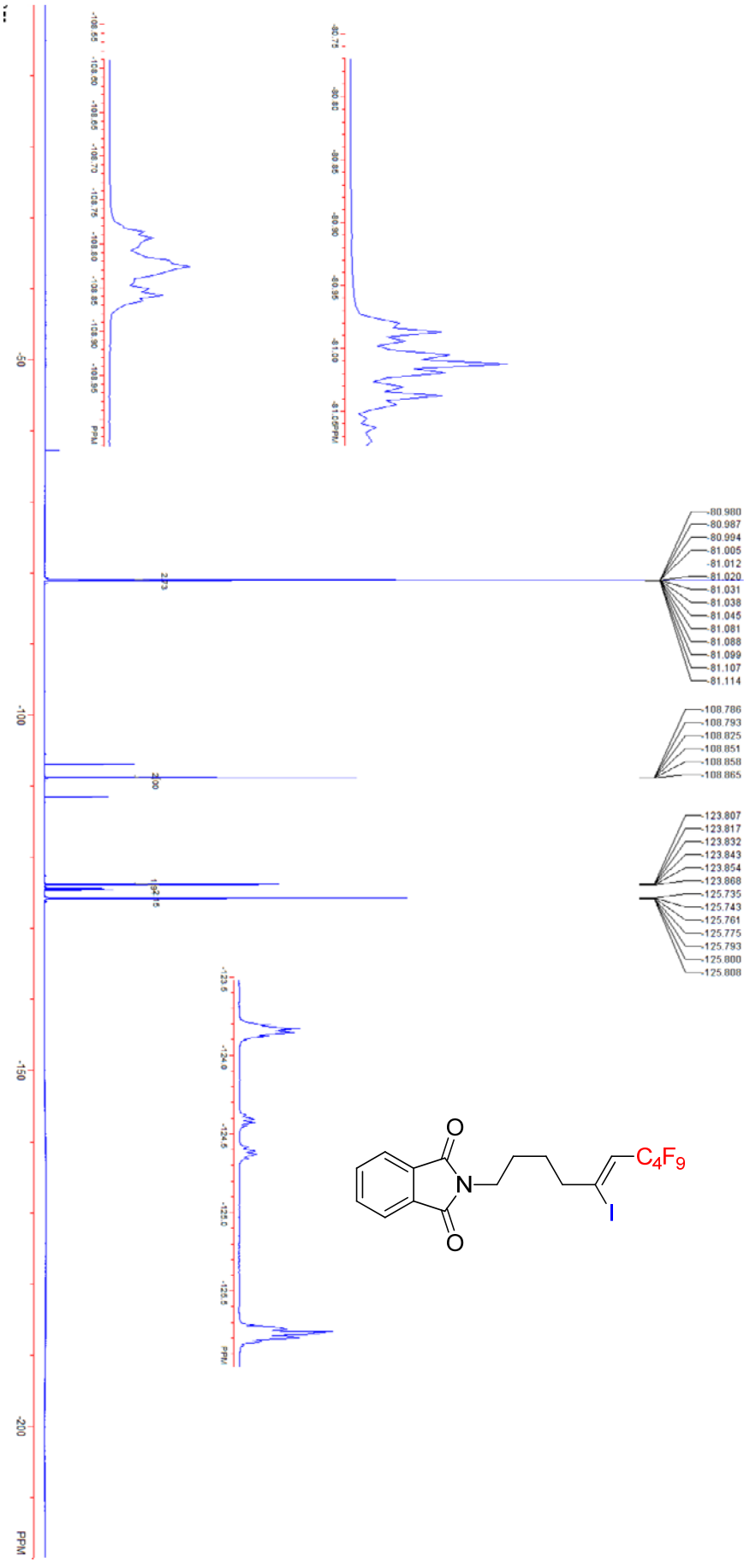
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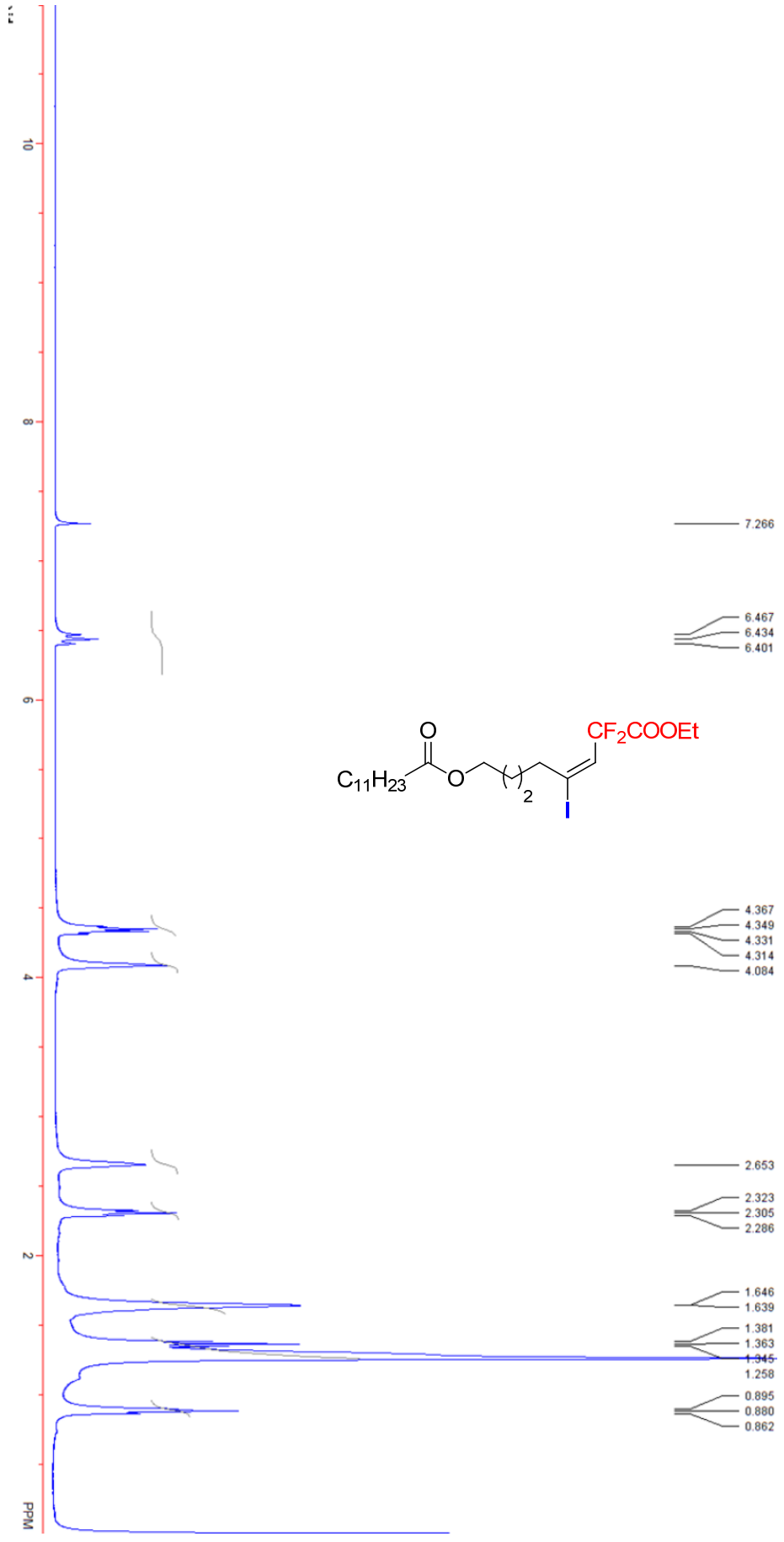
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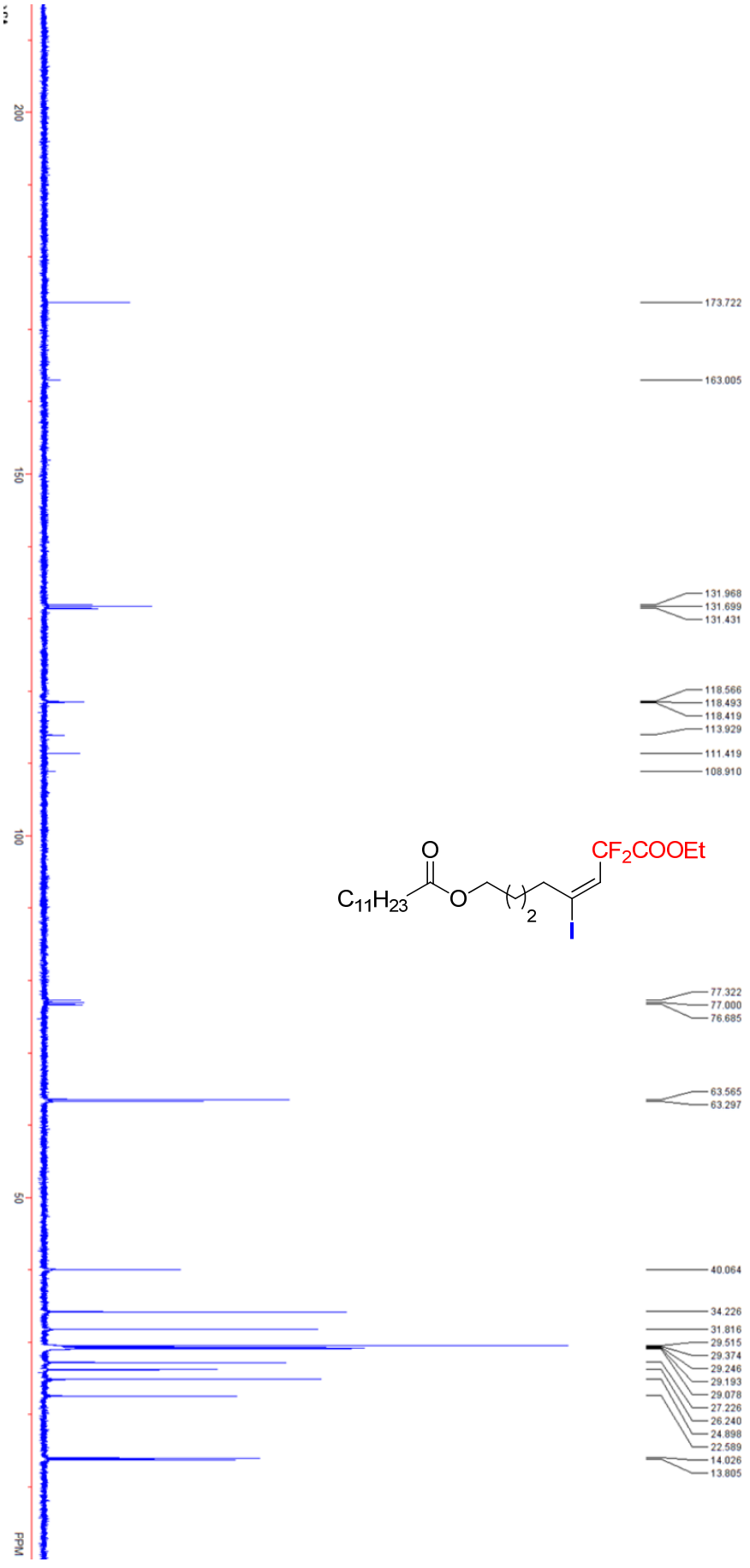
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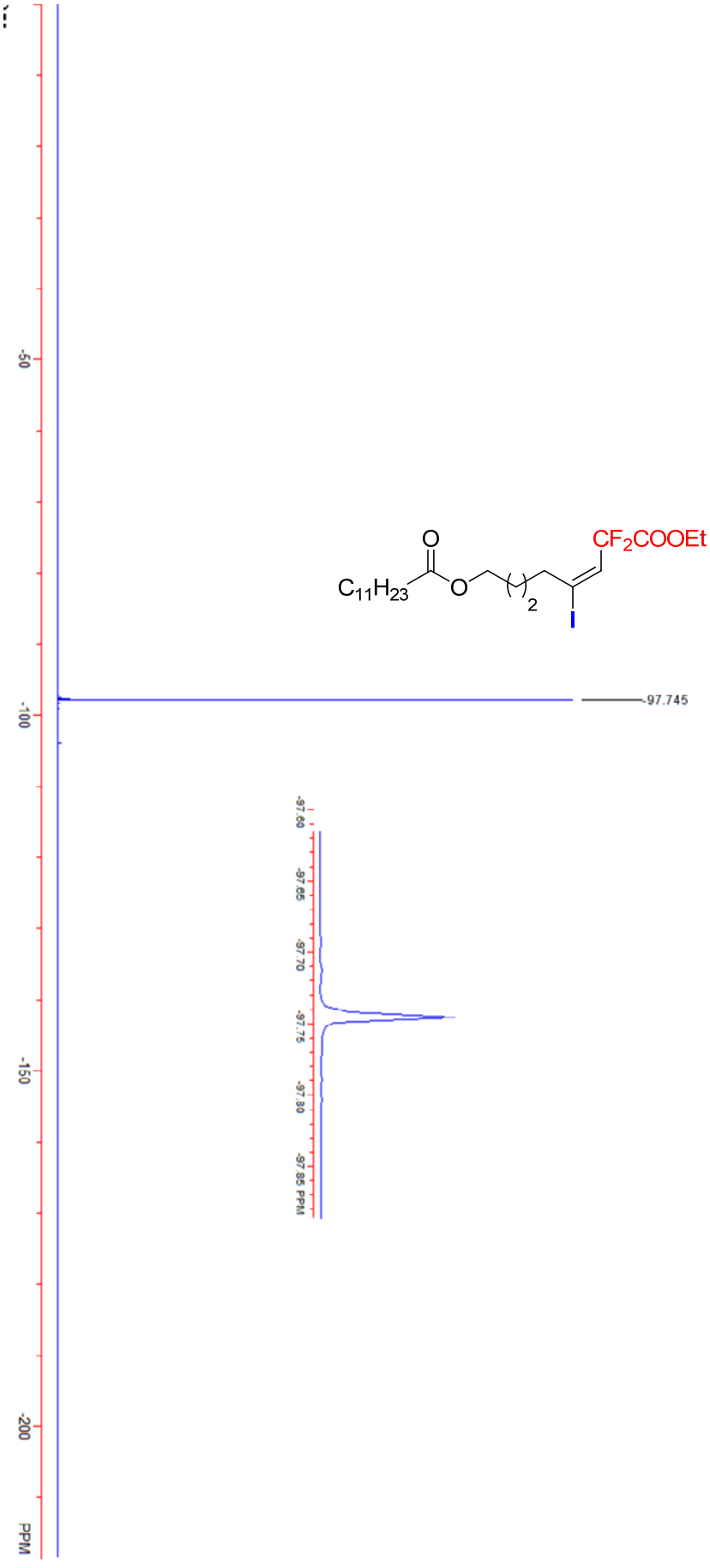
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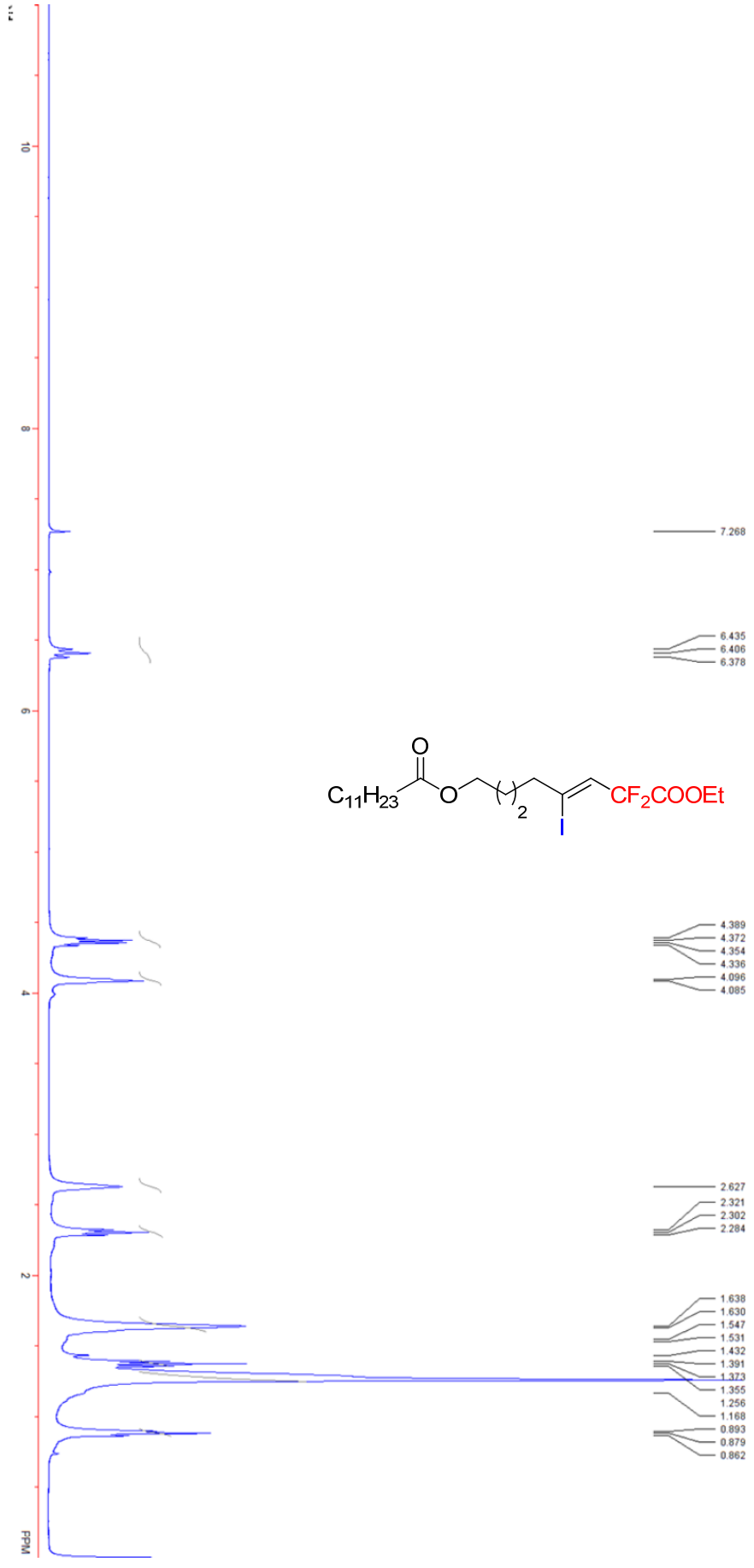
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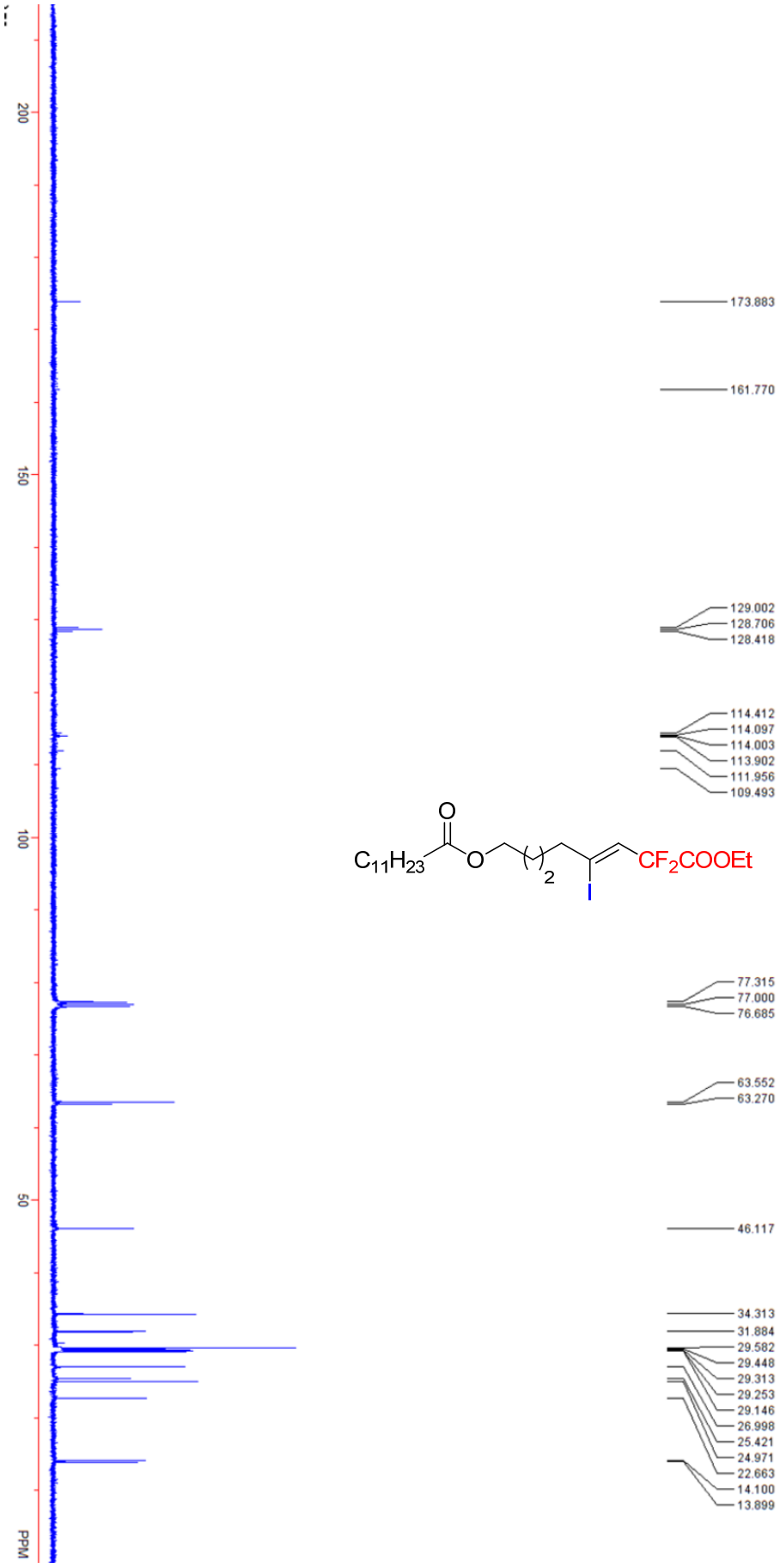
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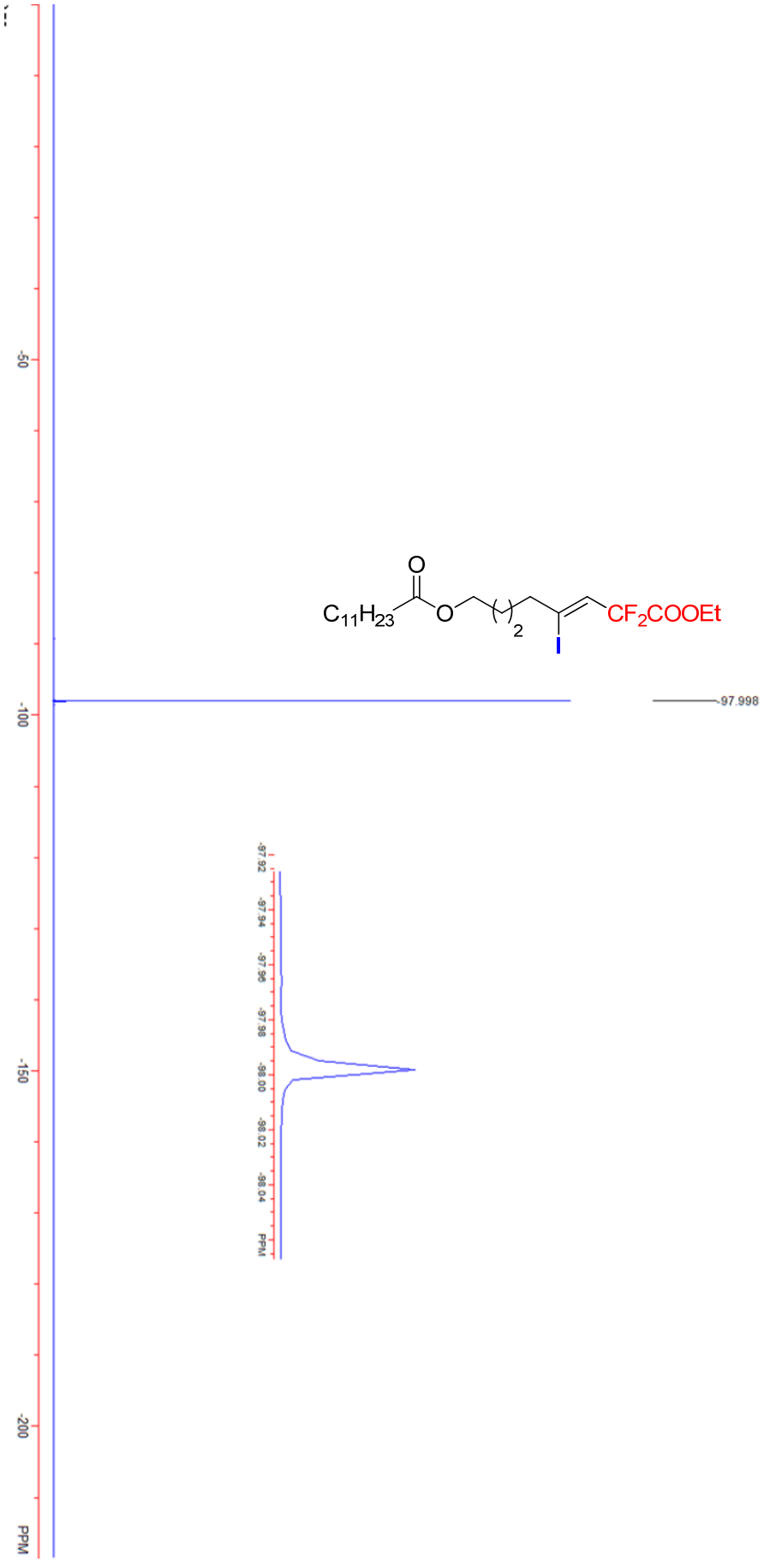
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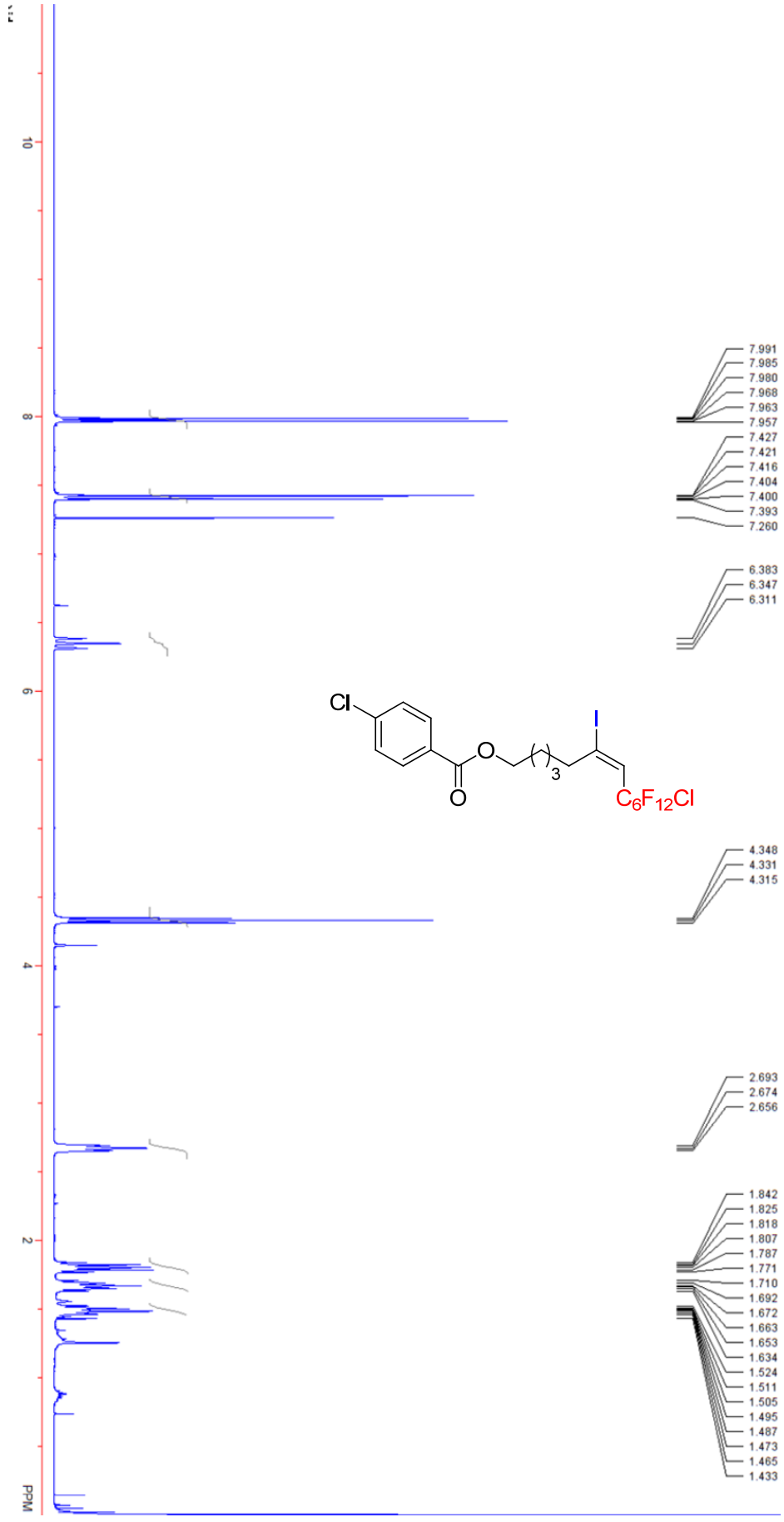
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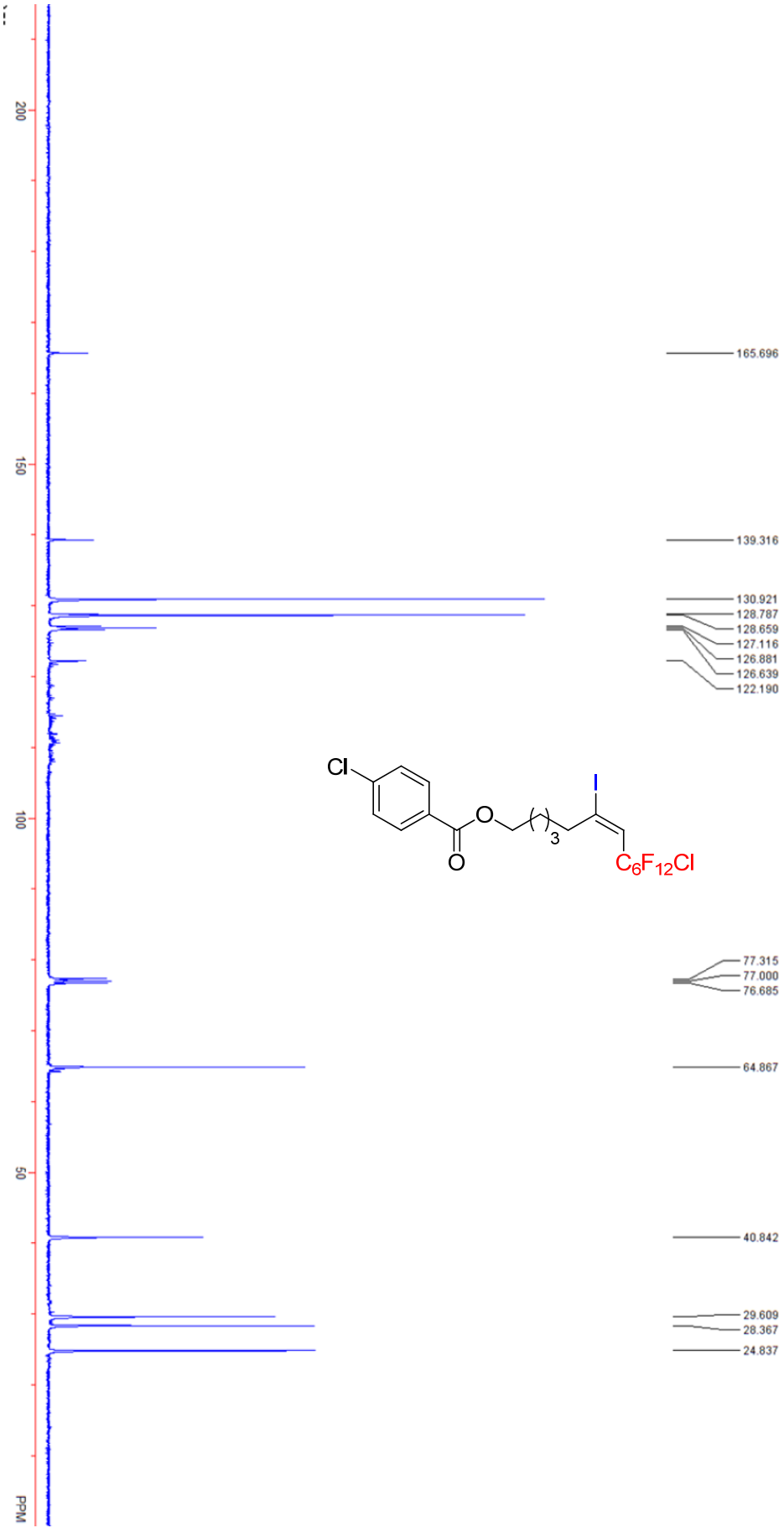
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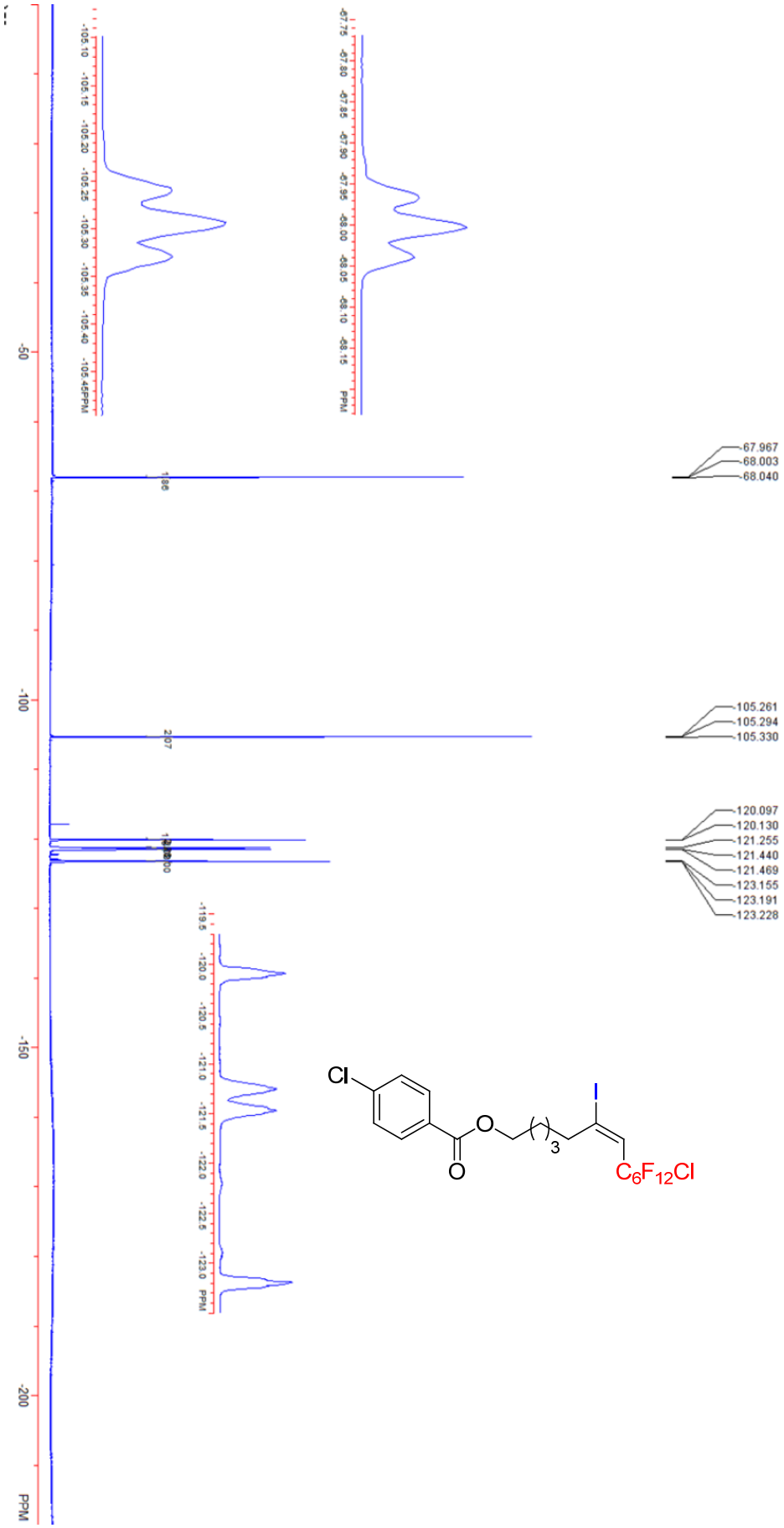
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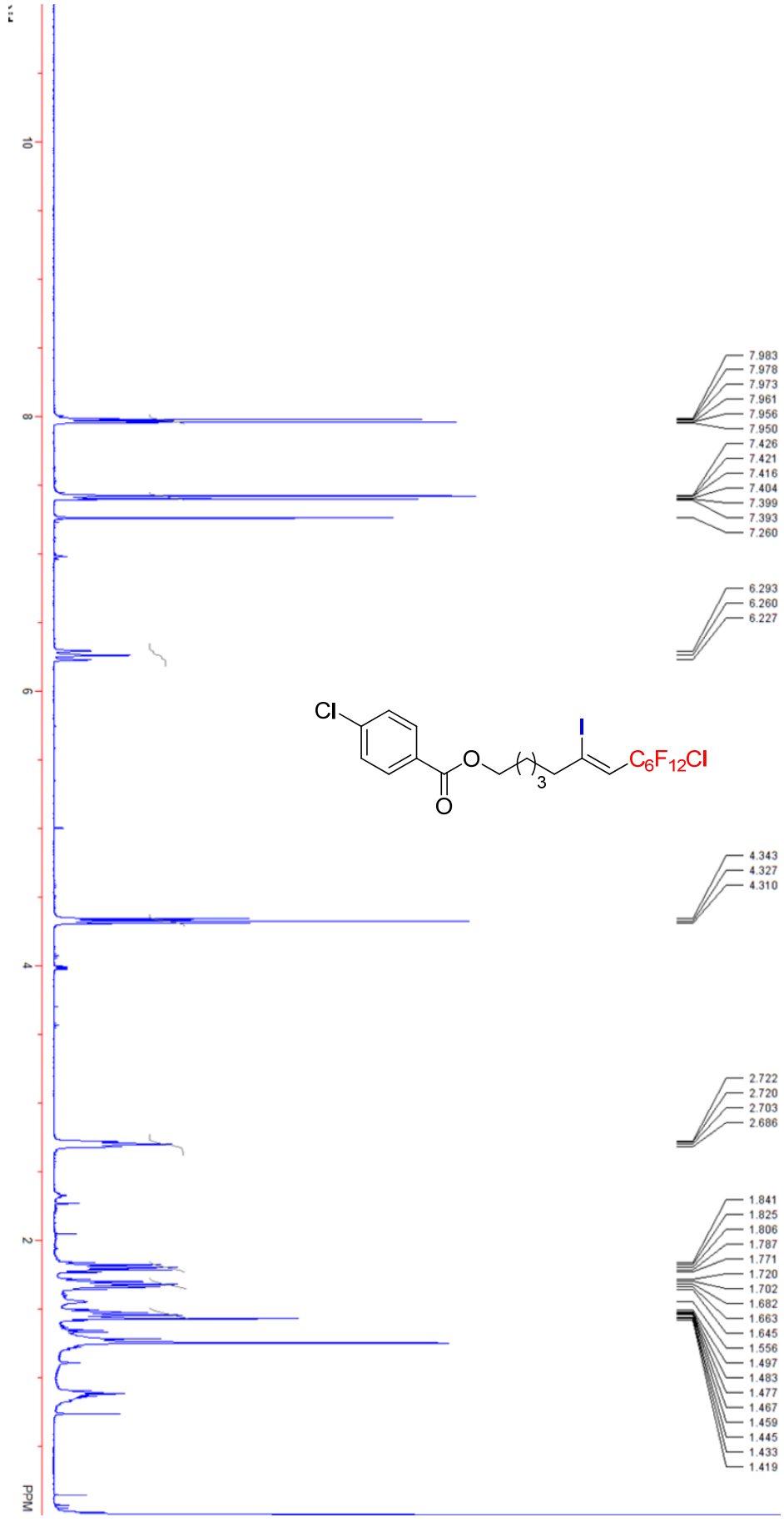
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1.556
1.497
1.483
1.477
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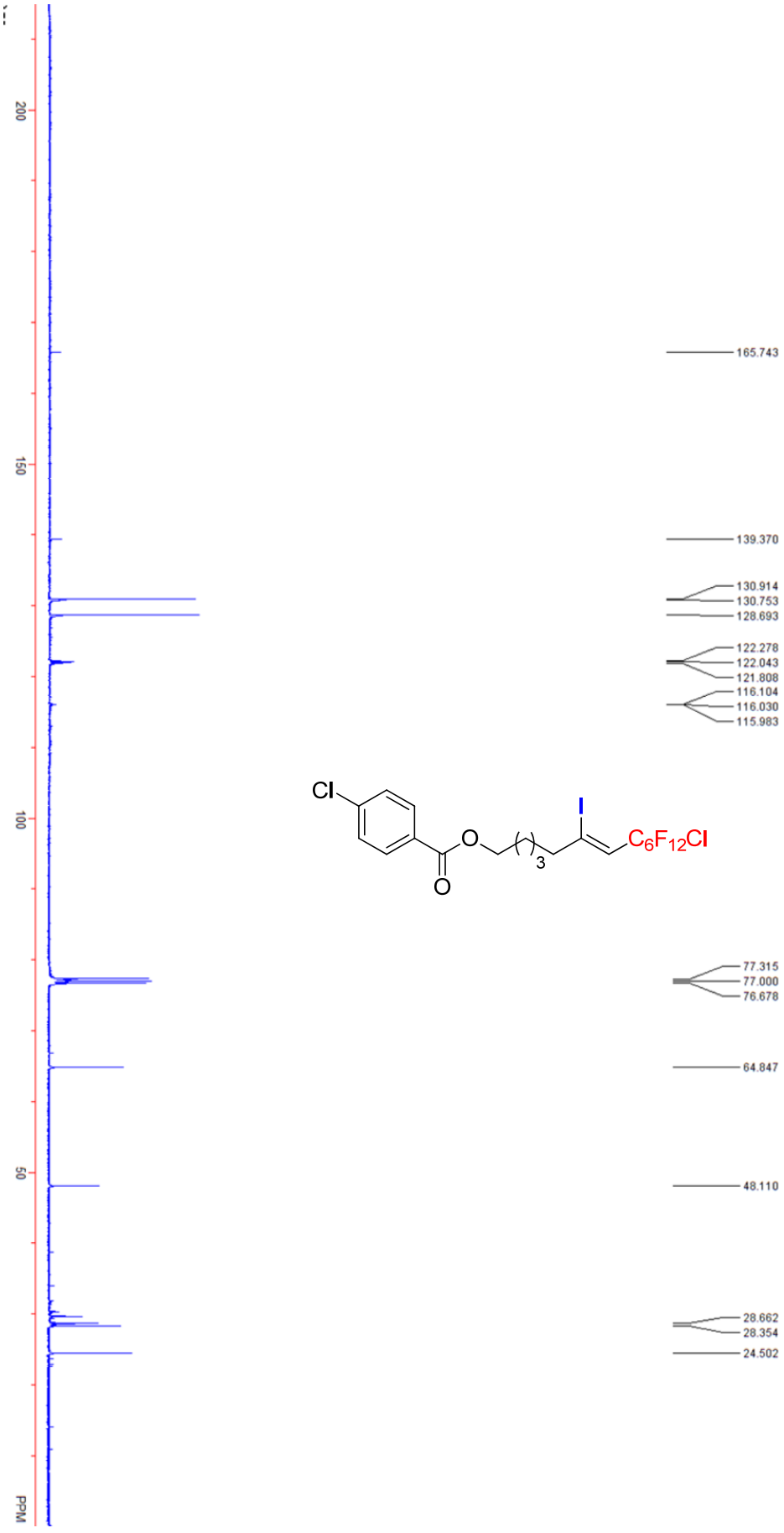
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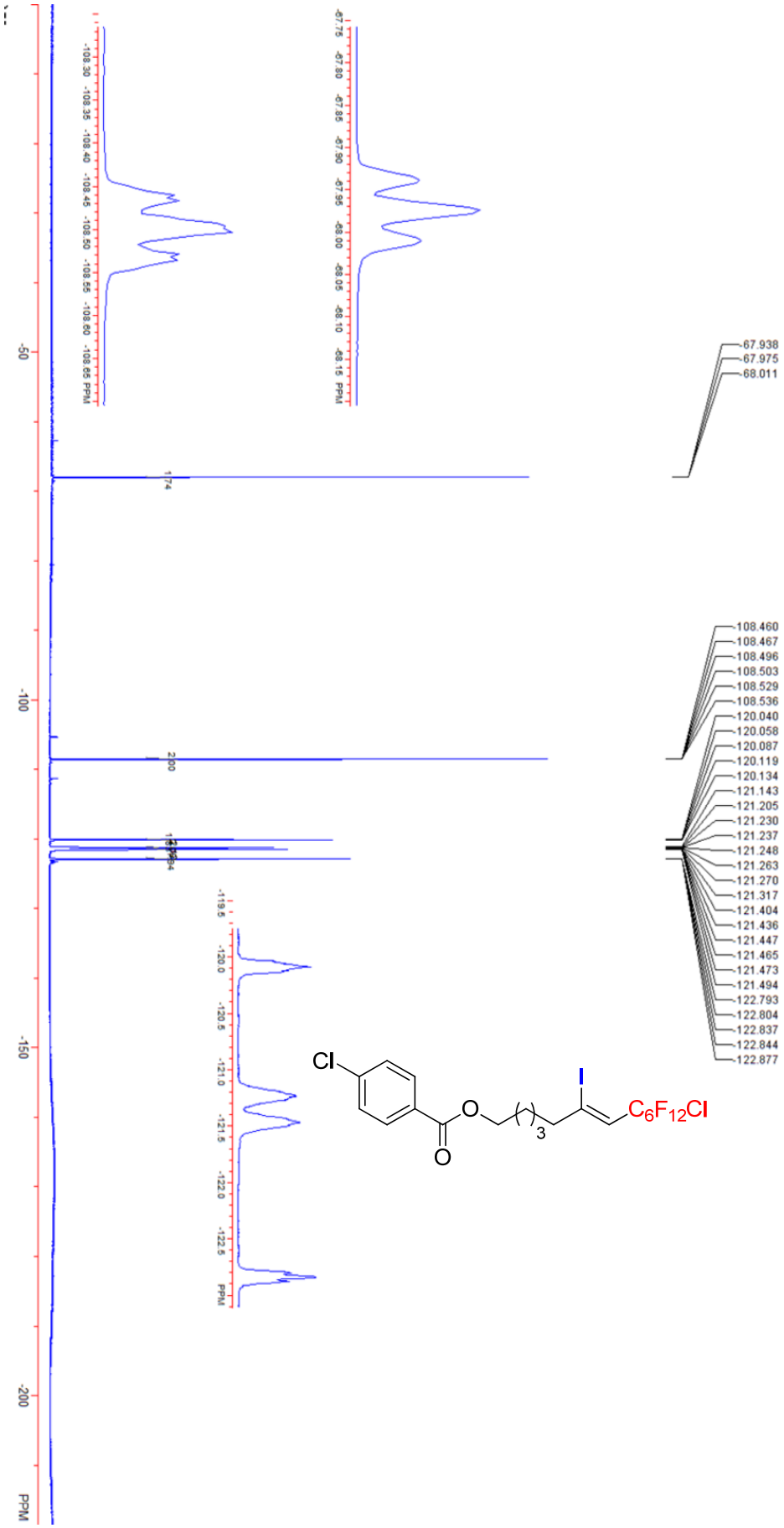
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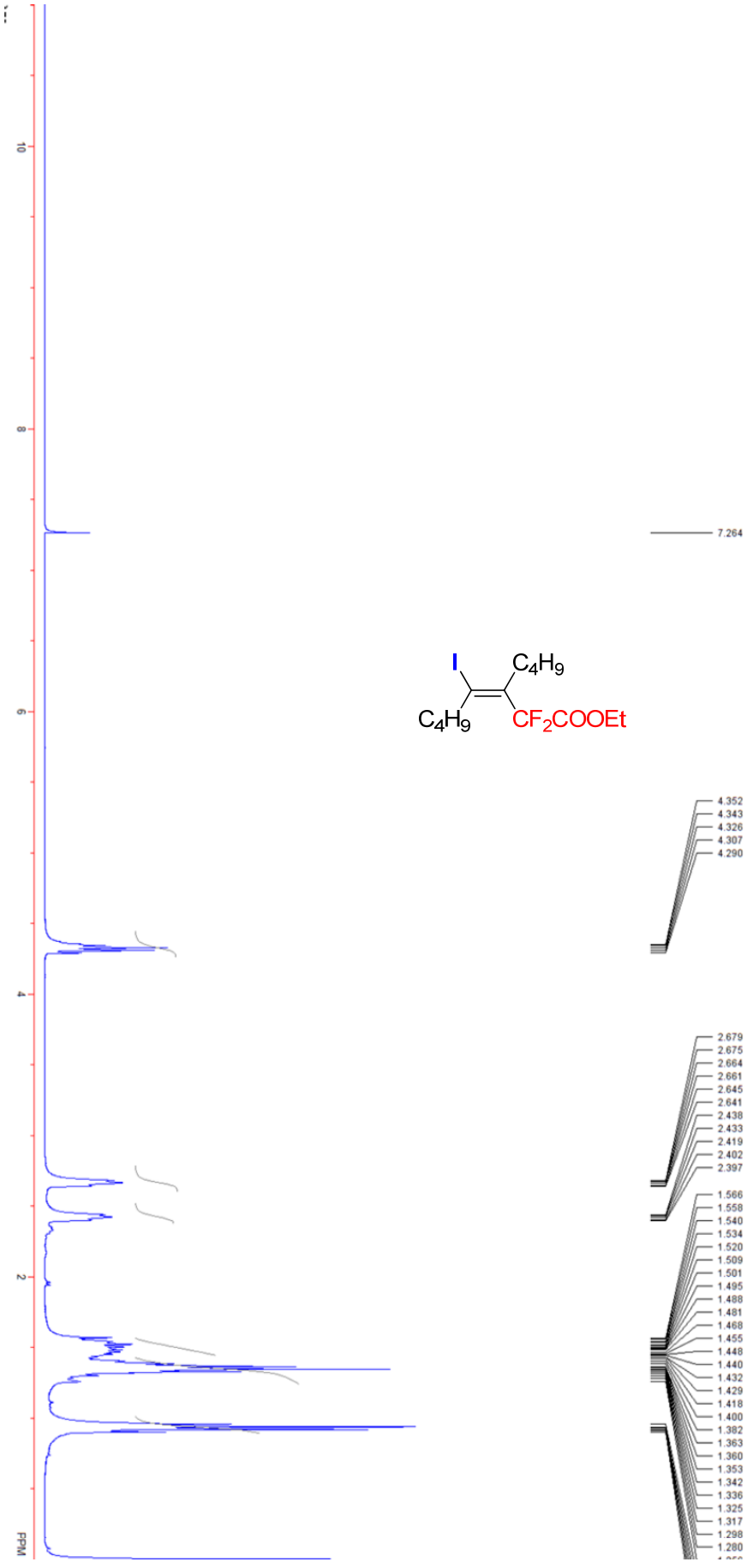
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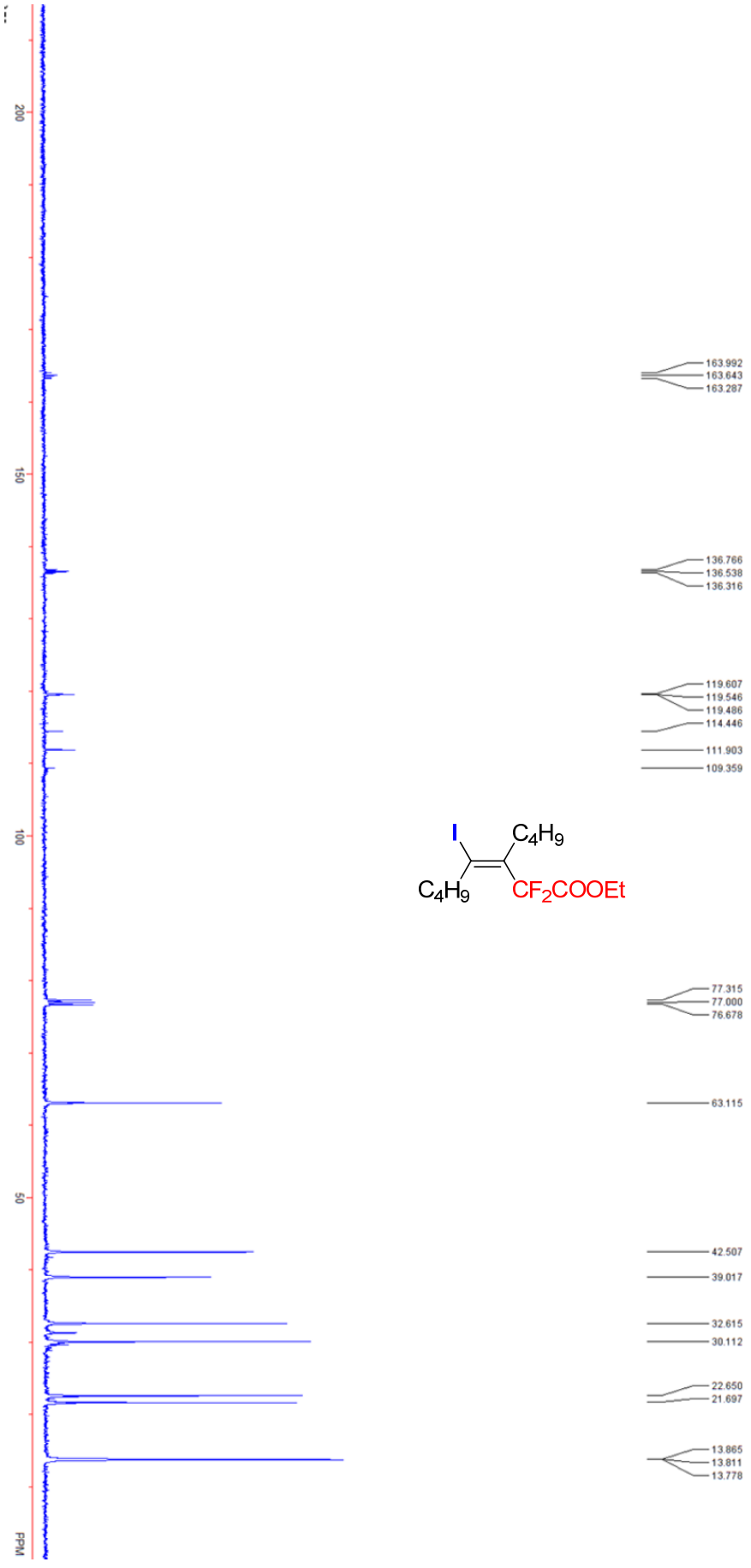
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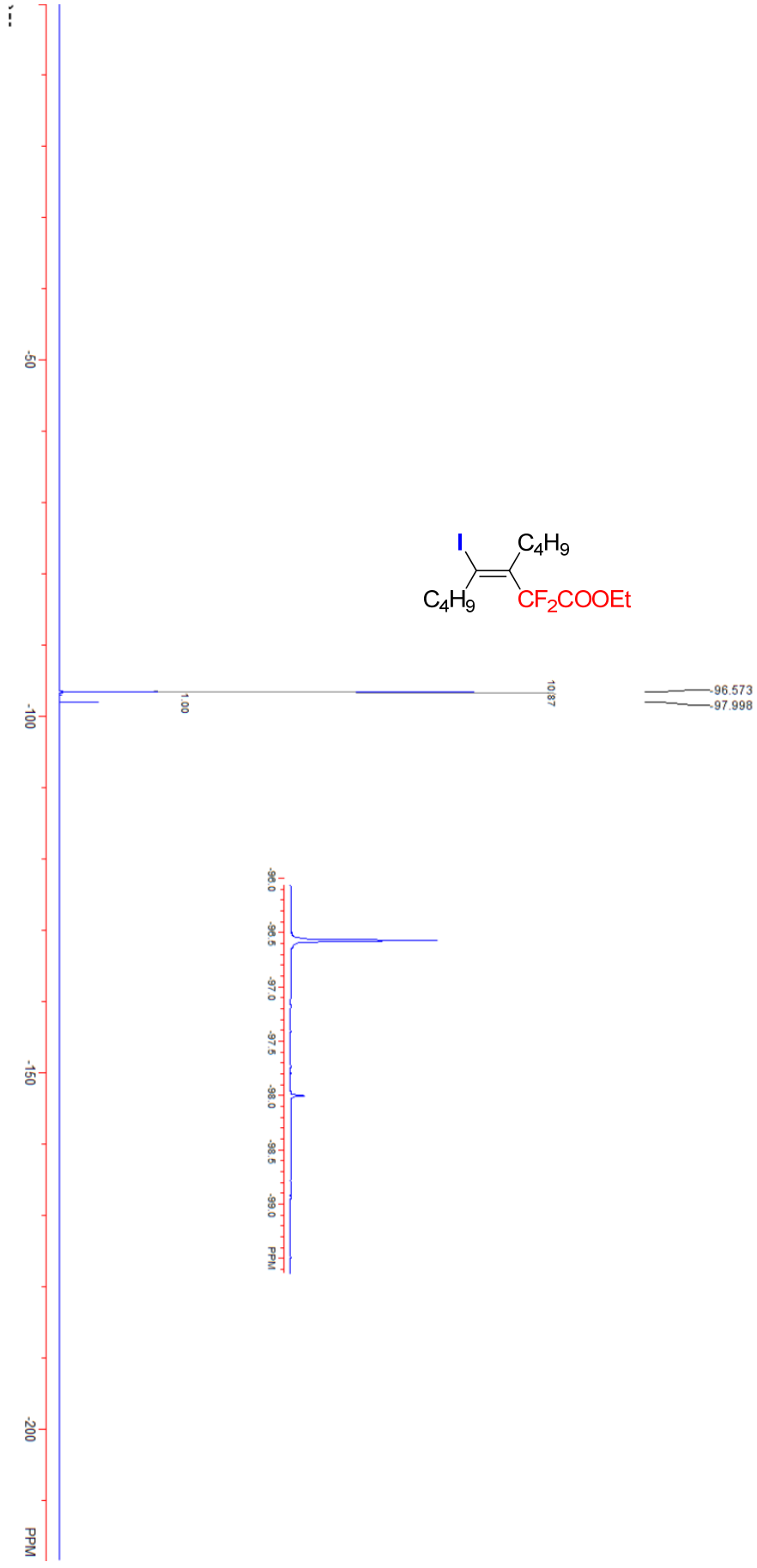
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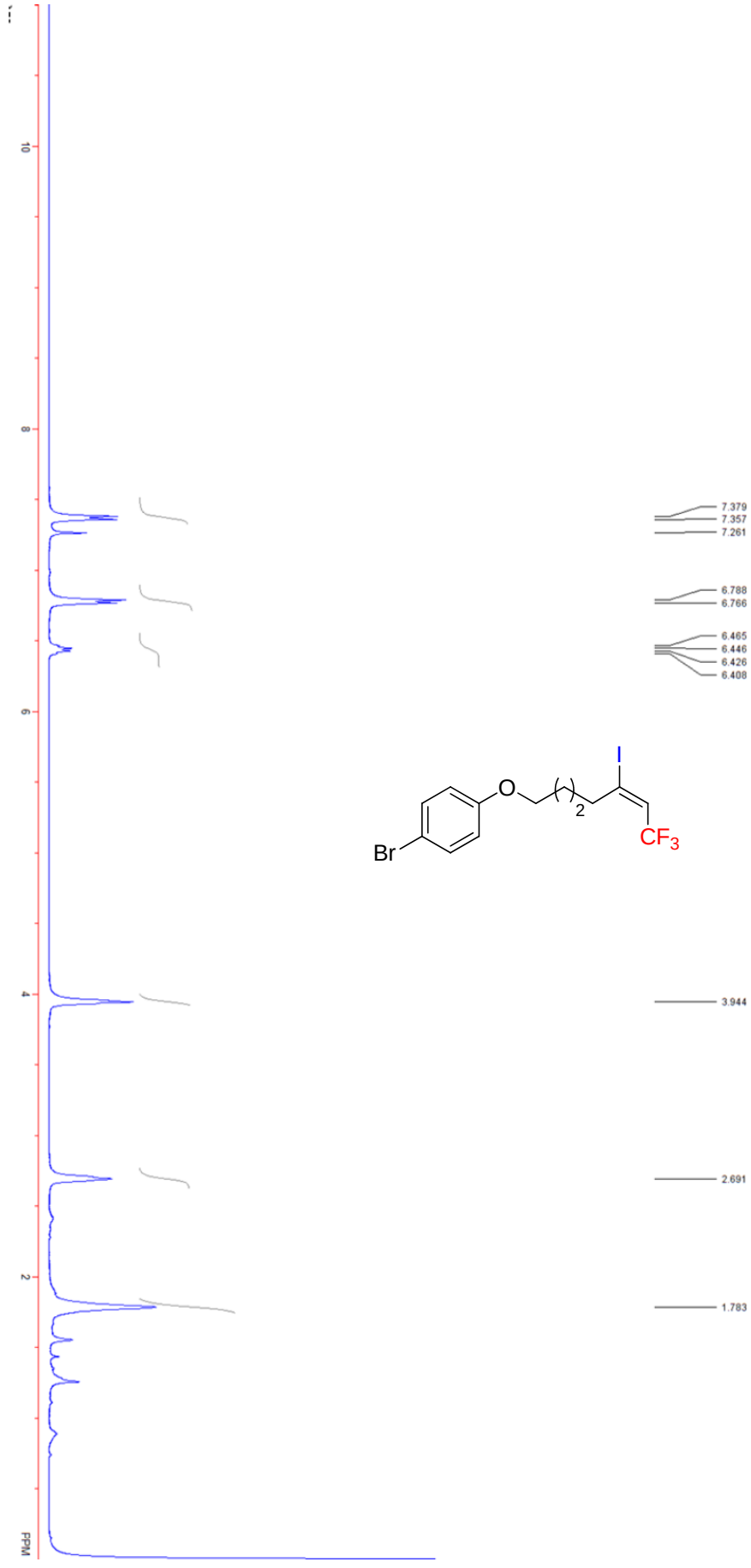
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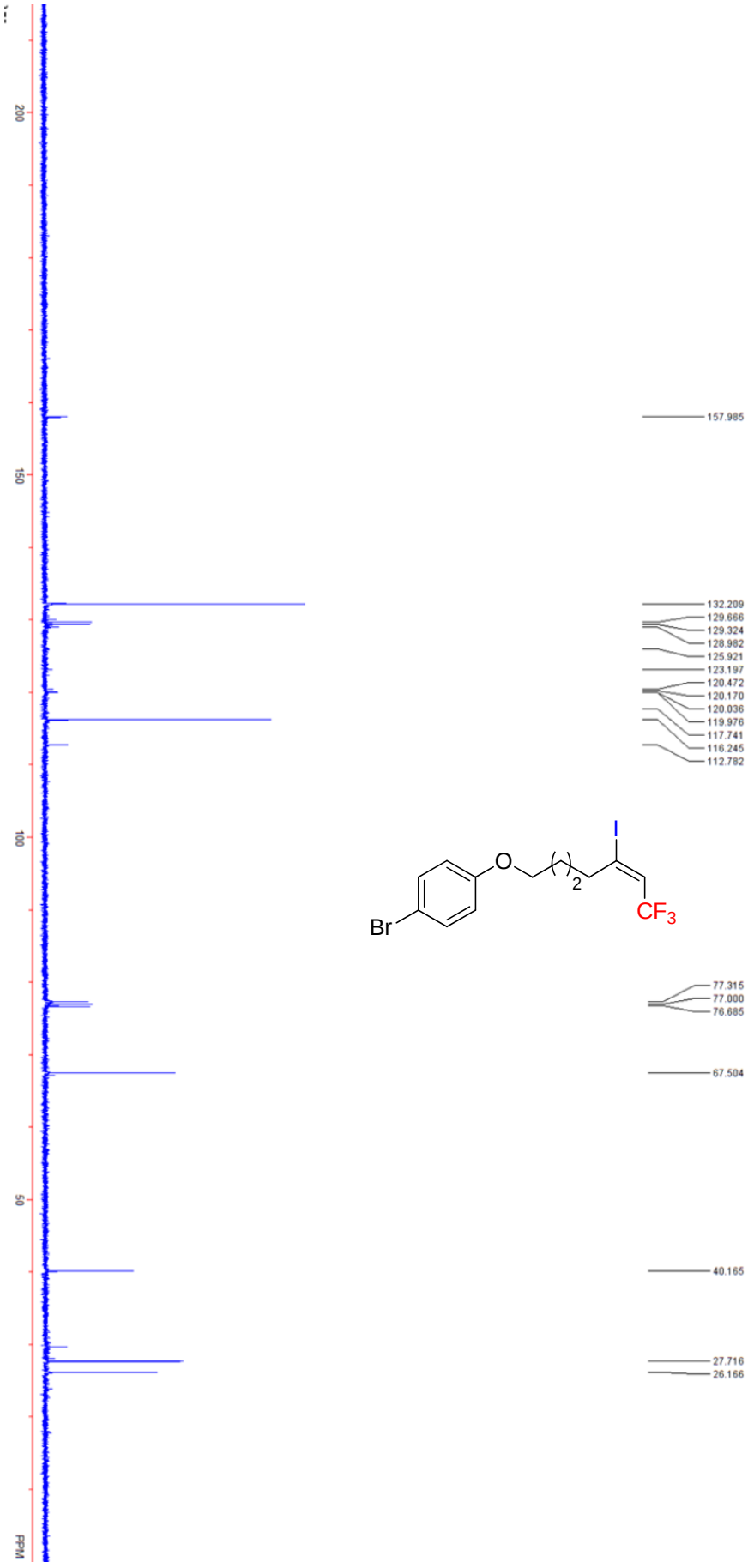
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112.782
77.315
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26.166
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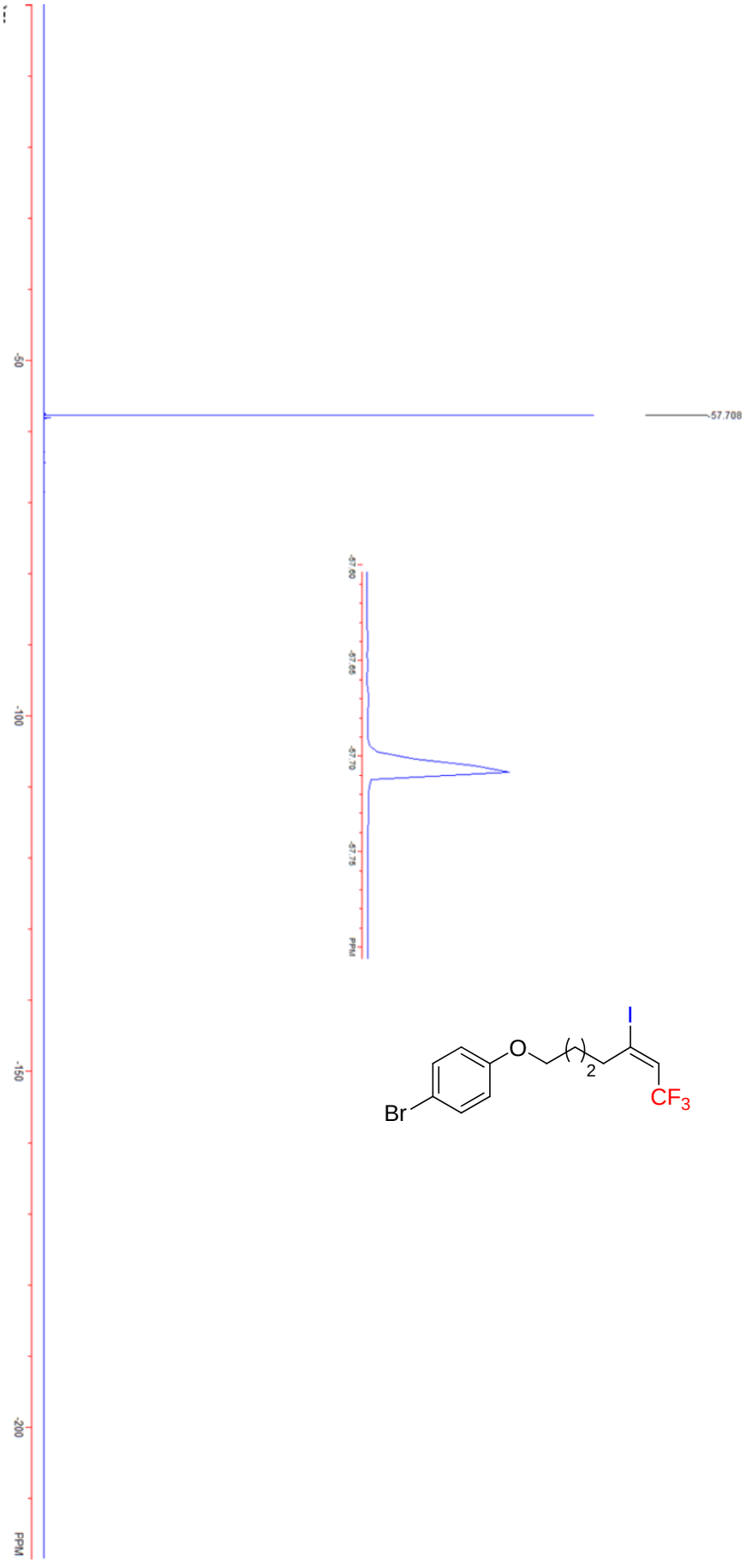
Br
CF3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PPM

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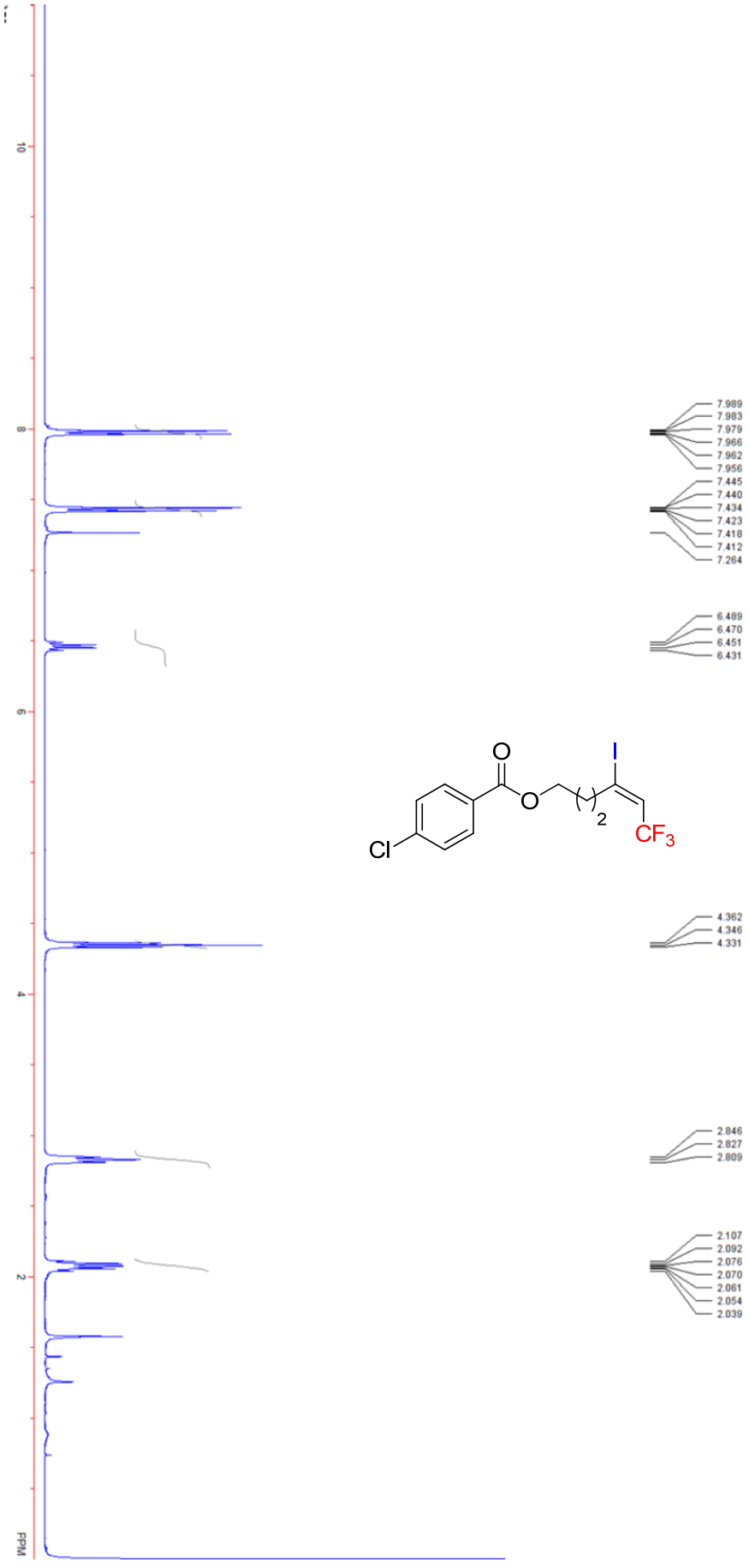
Br
CF3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7.412
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6.451
6.431
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4.346
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2.054
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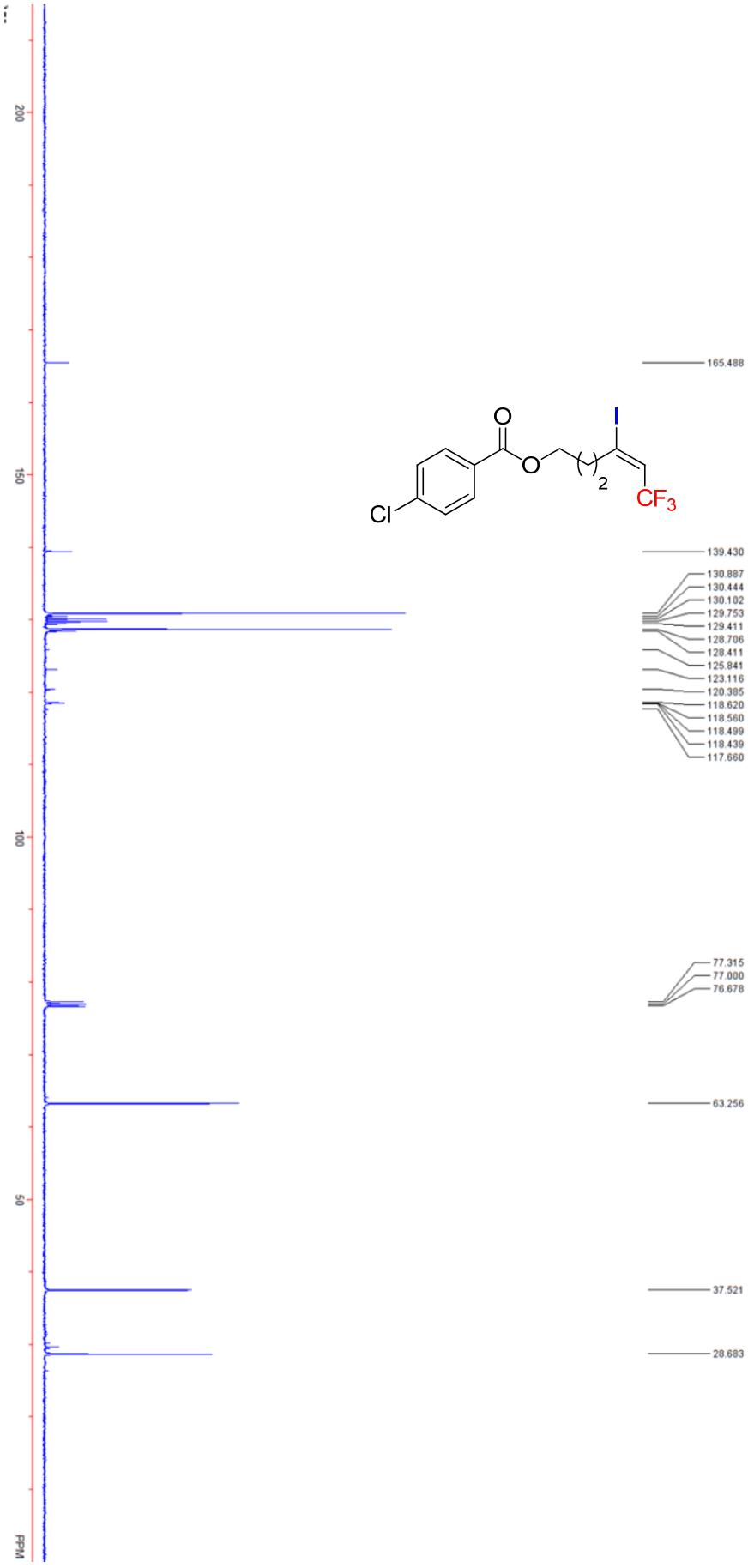
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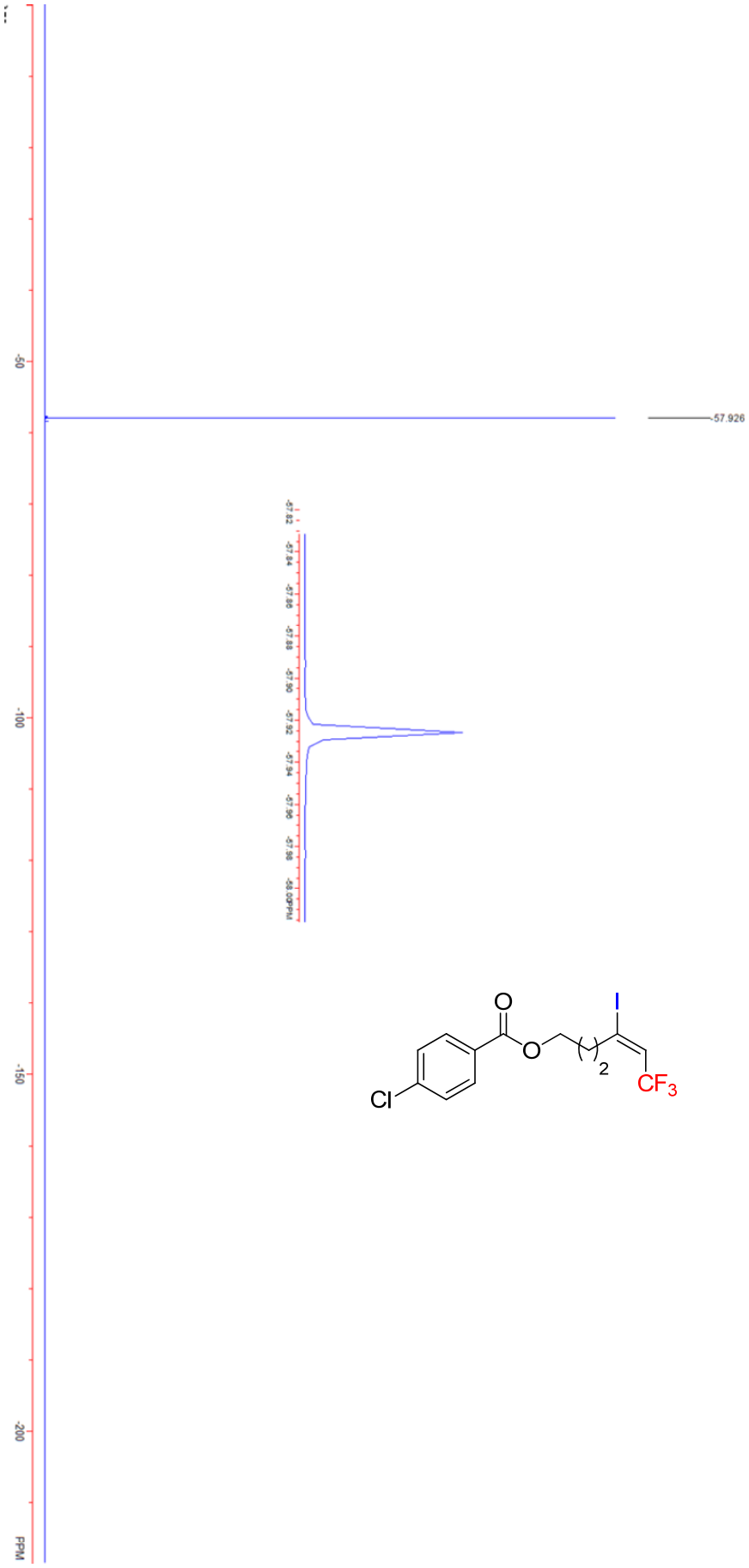
CF3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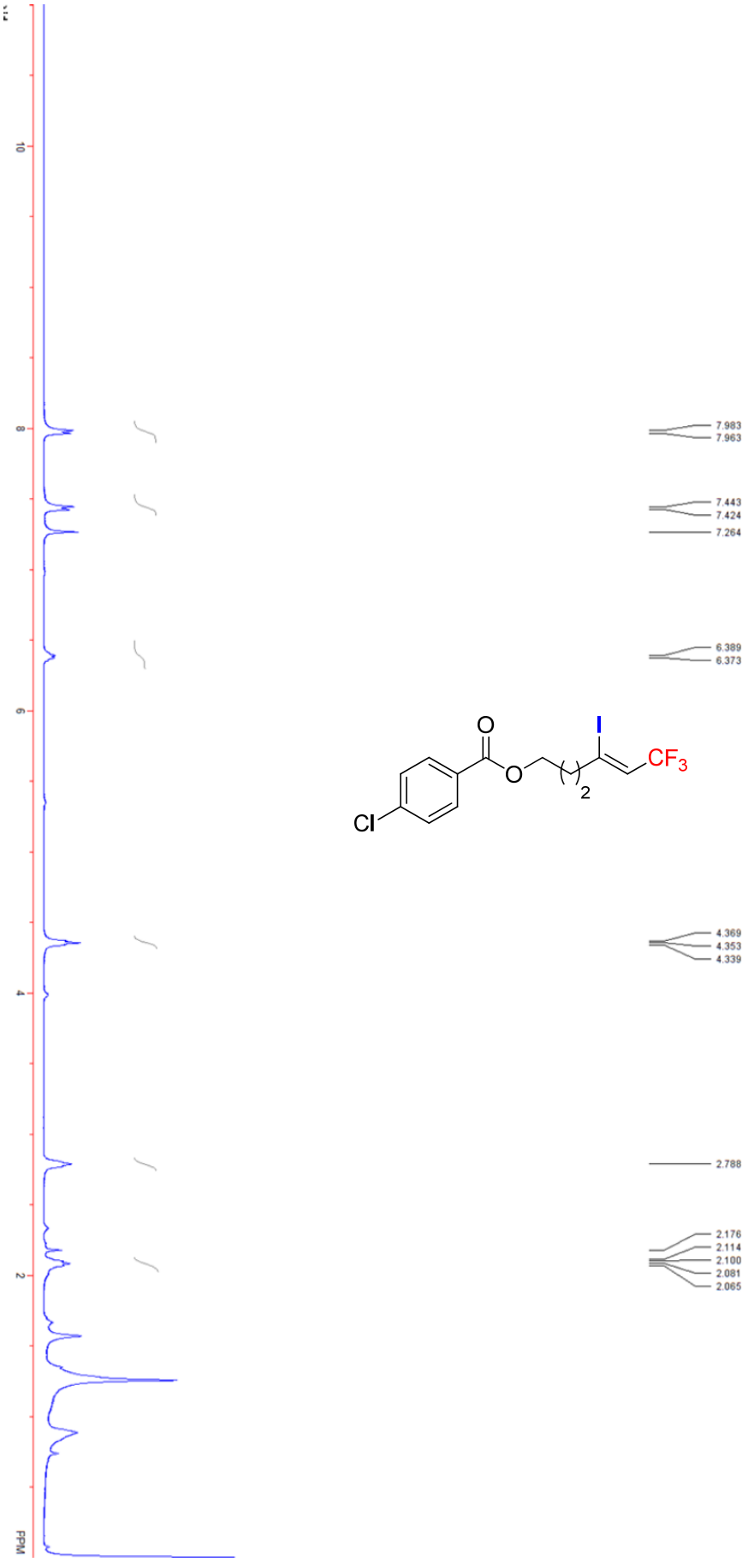
I
2
Cl
CF3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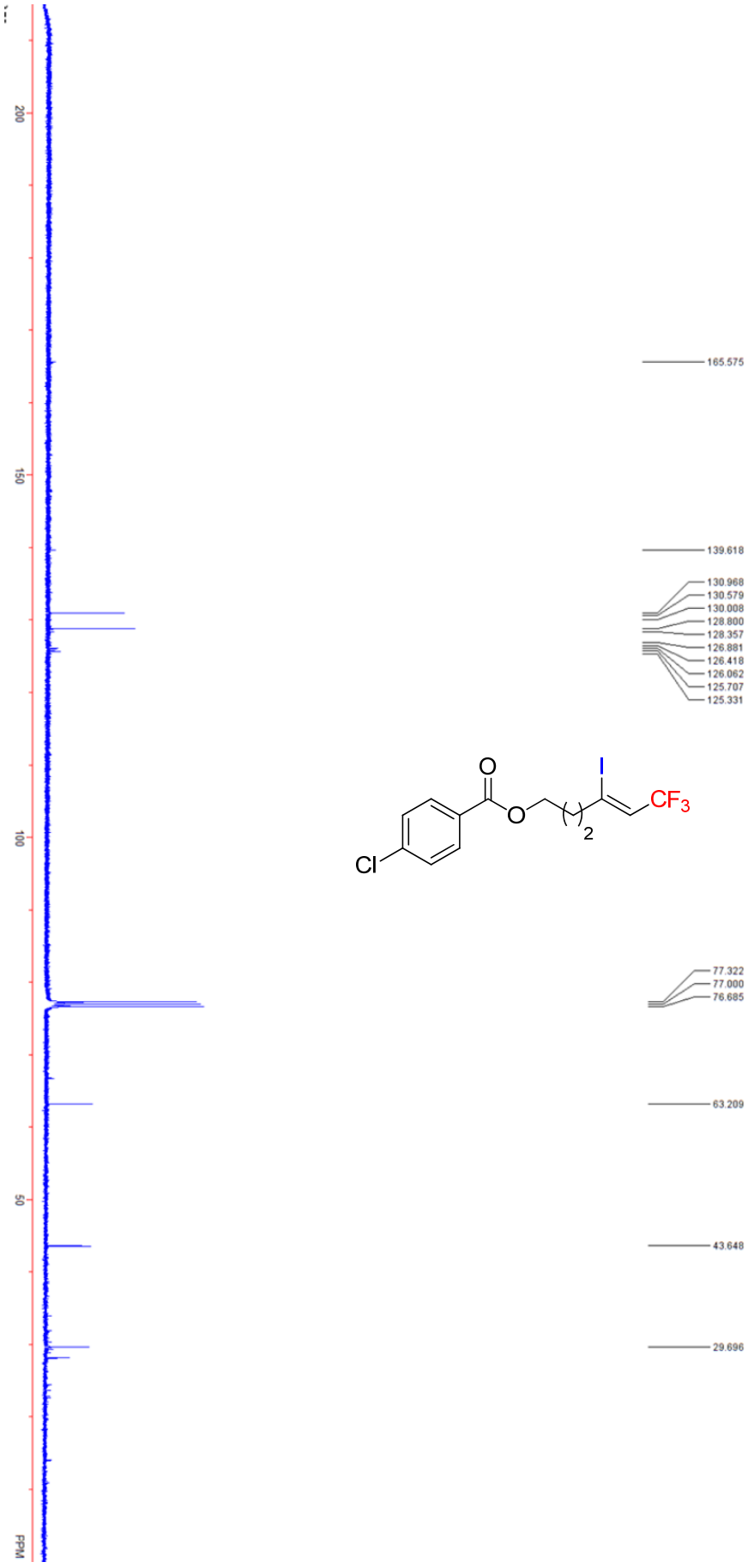
2.065
PPM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CF3
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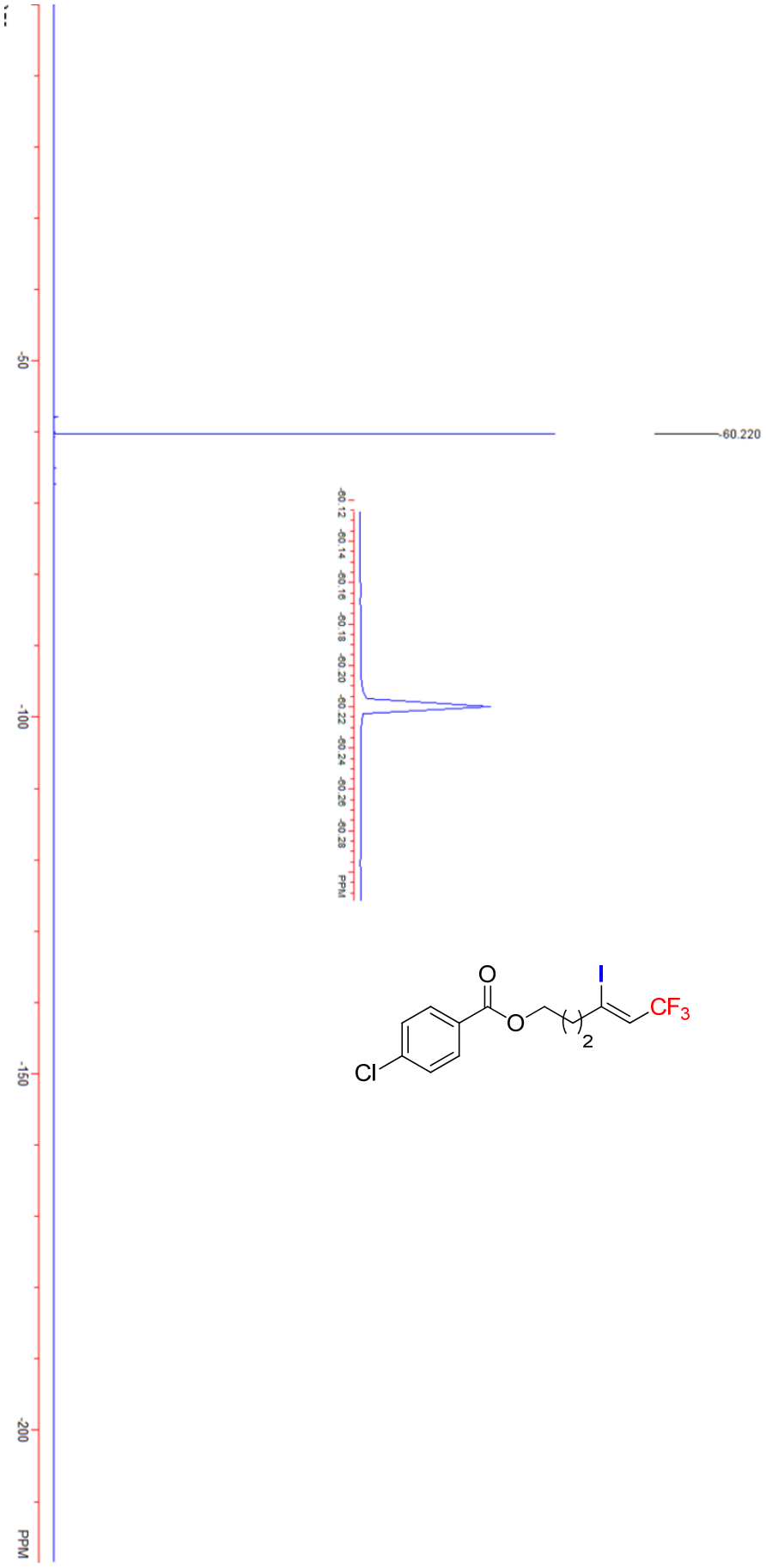
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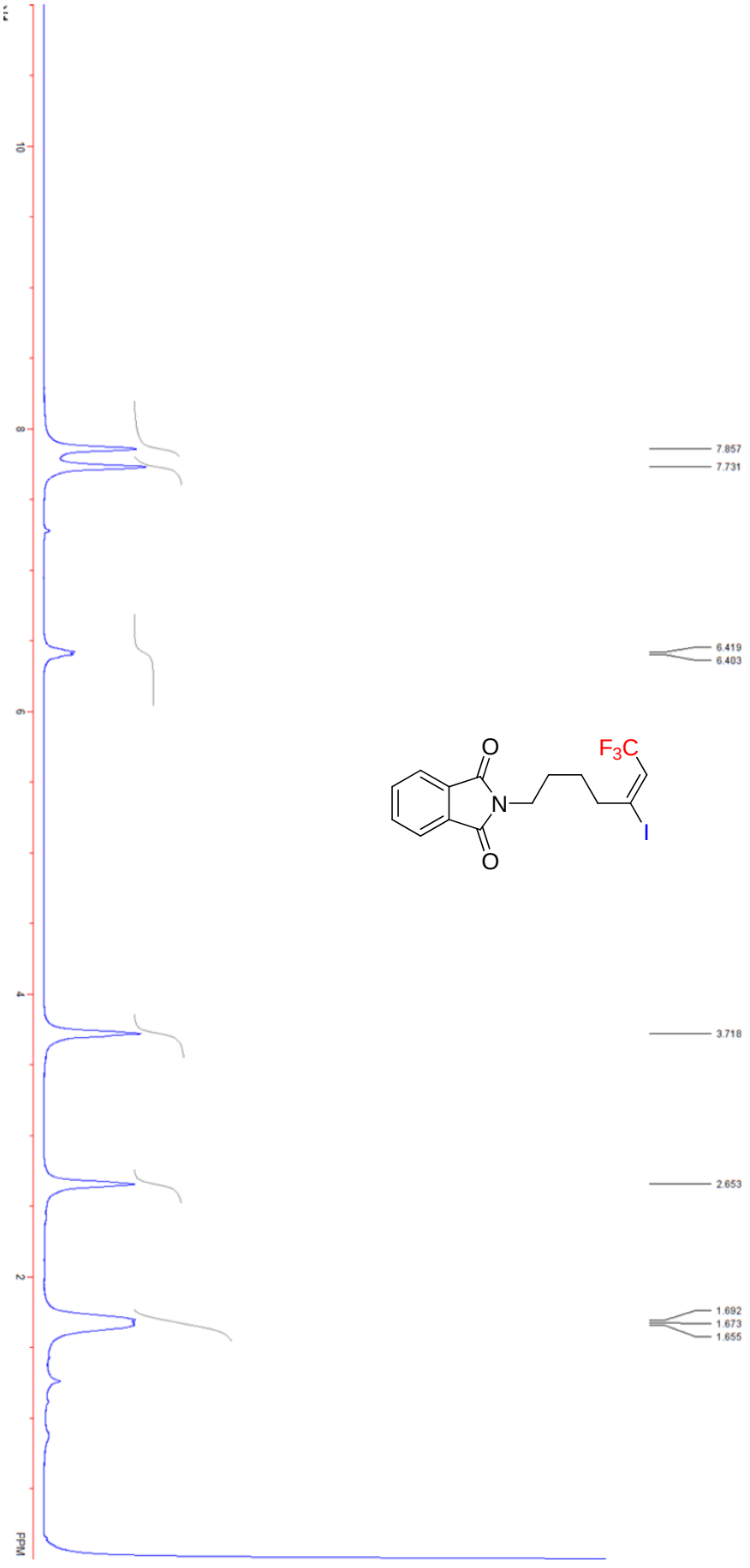
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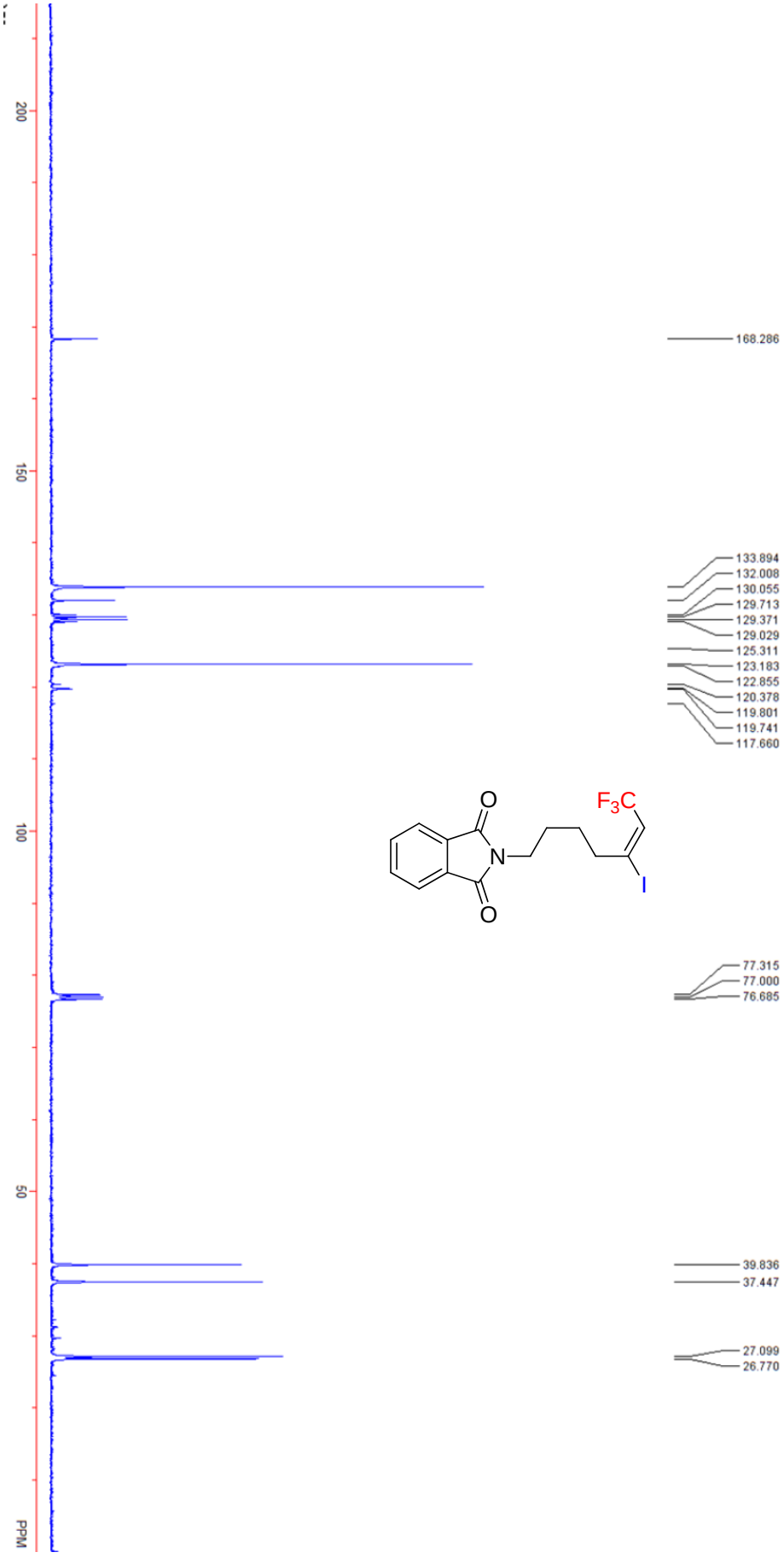
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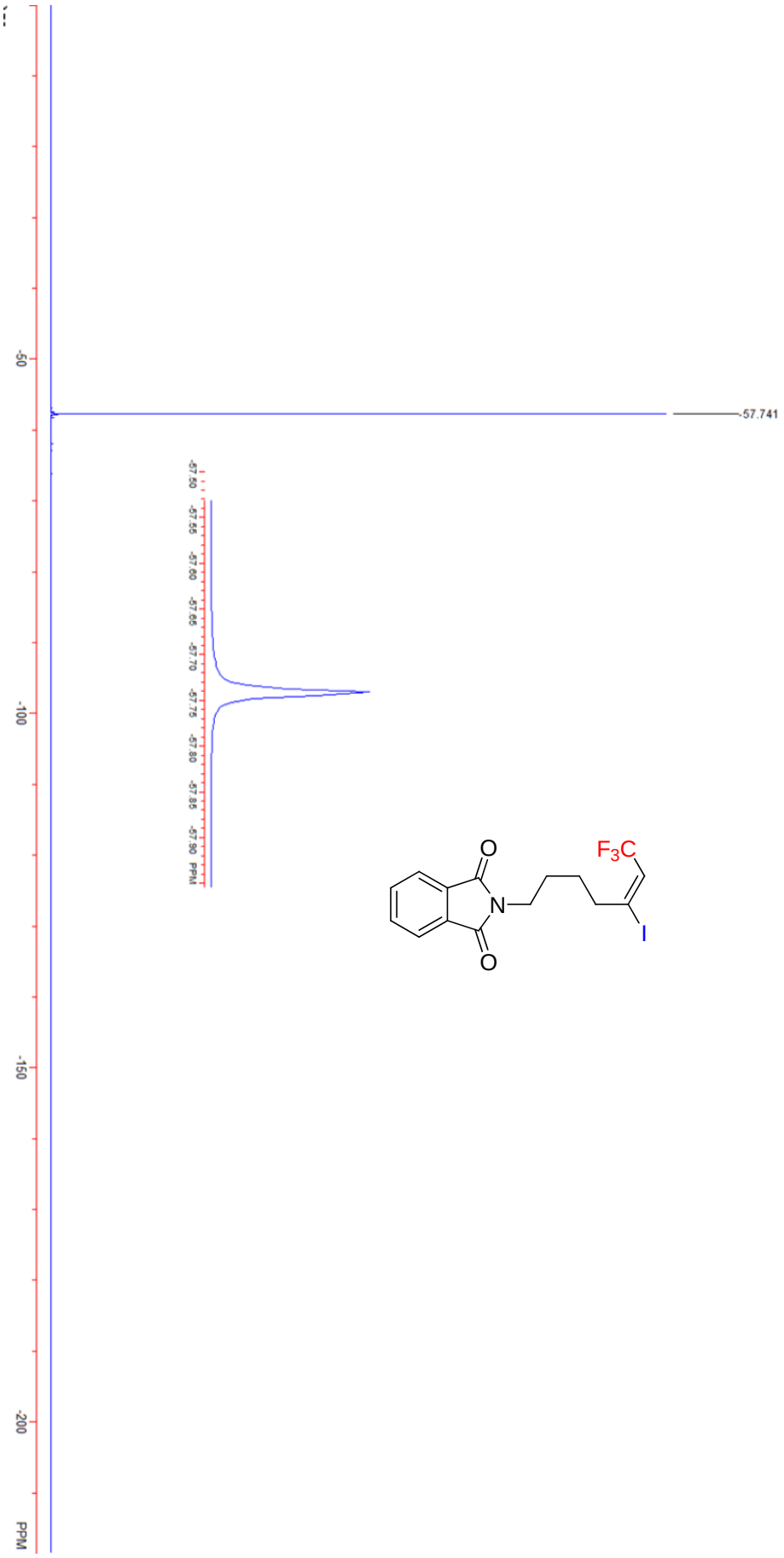
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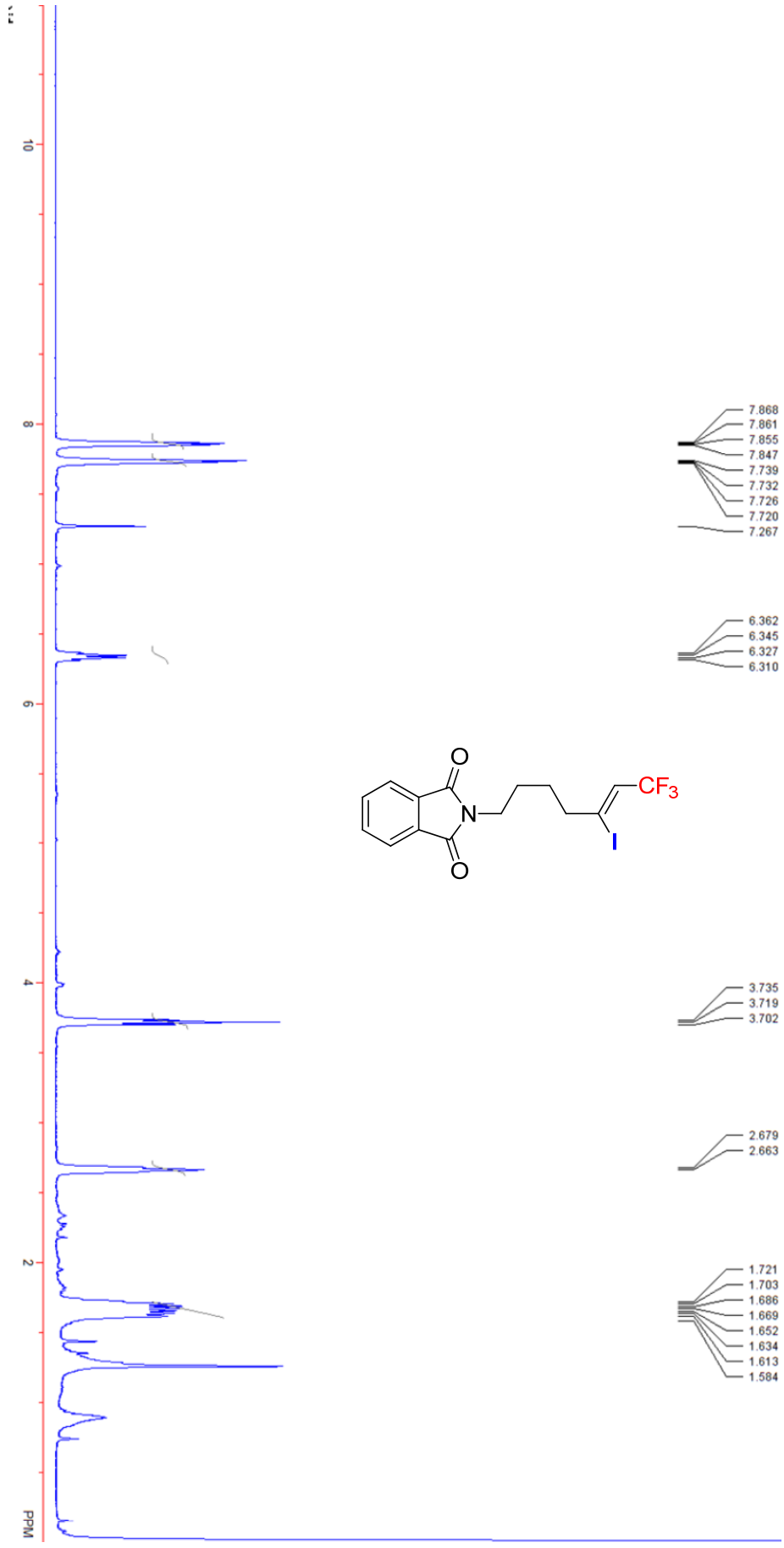
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3.702
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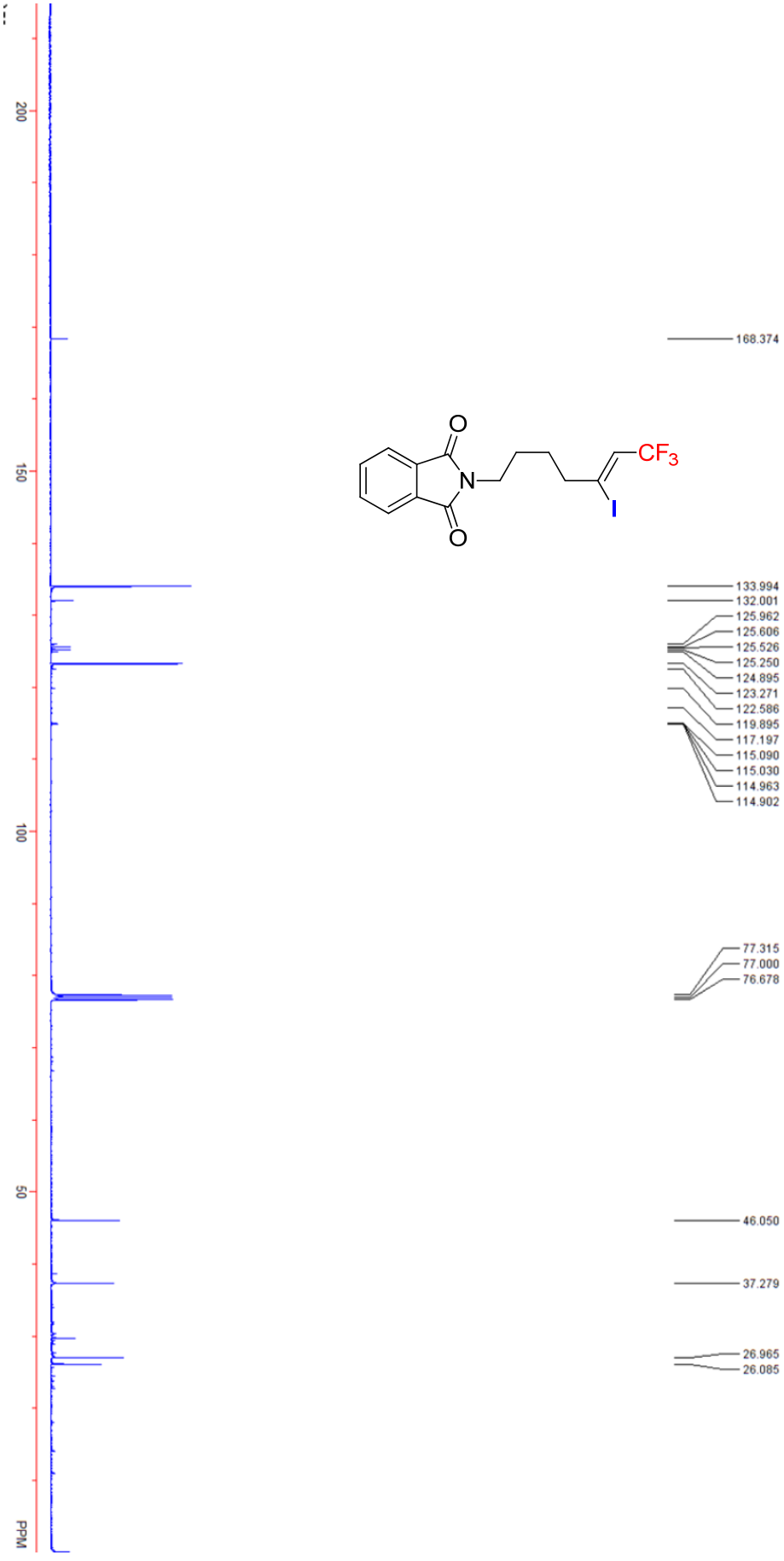
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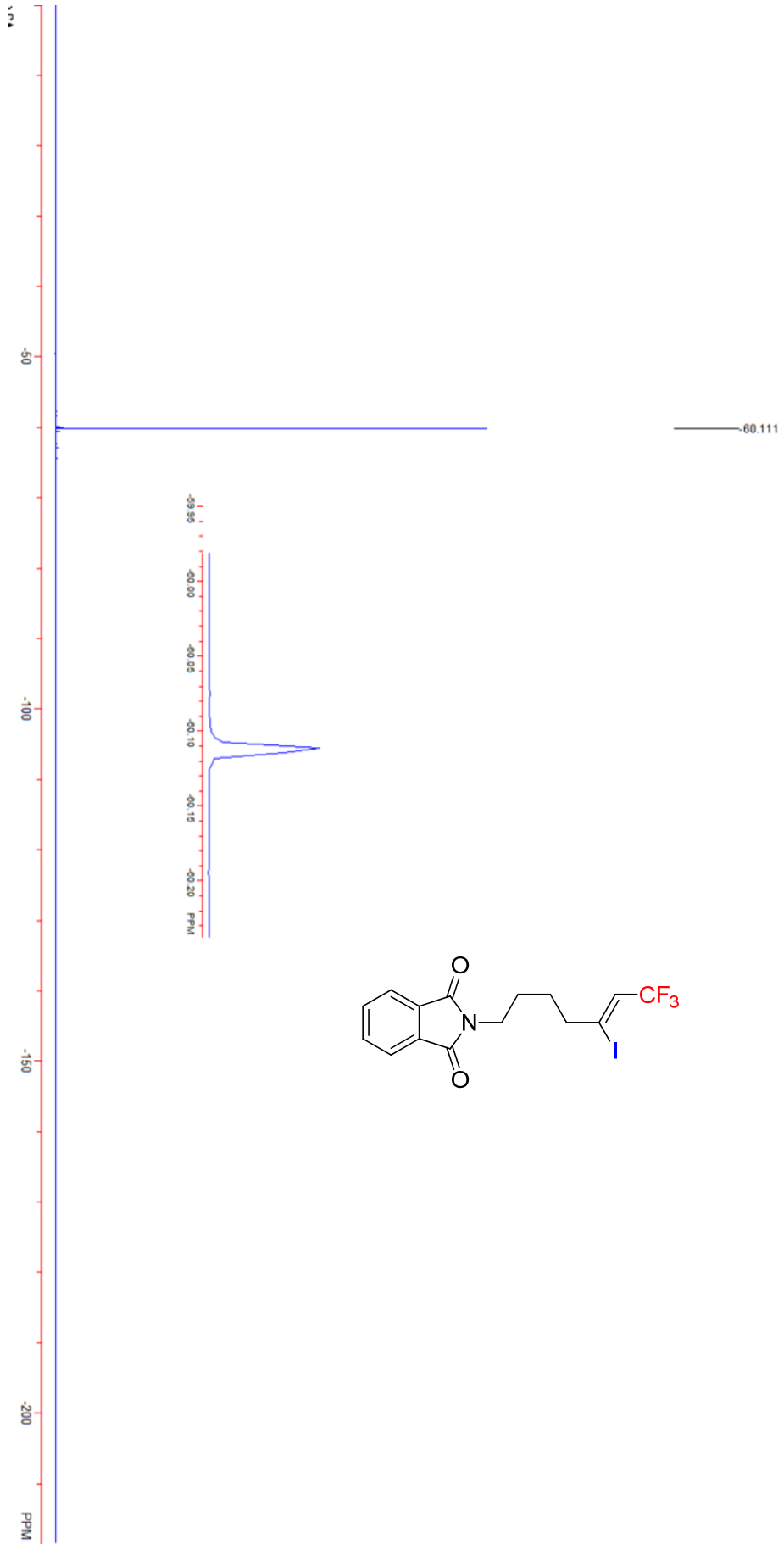
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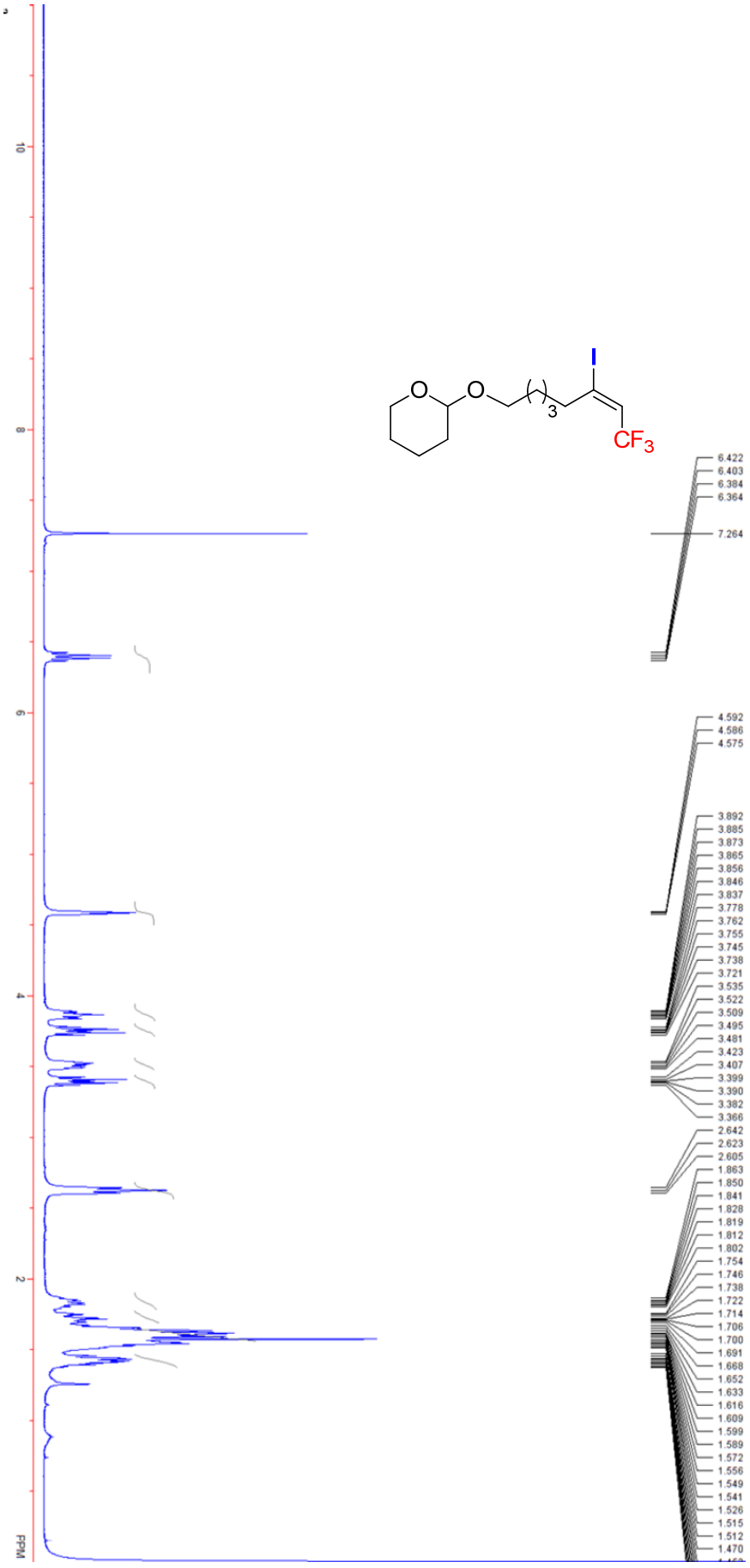
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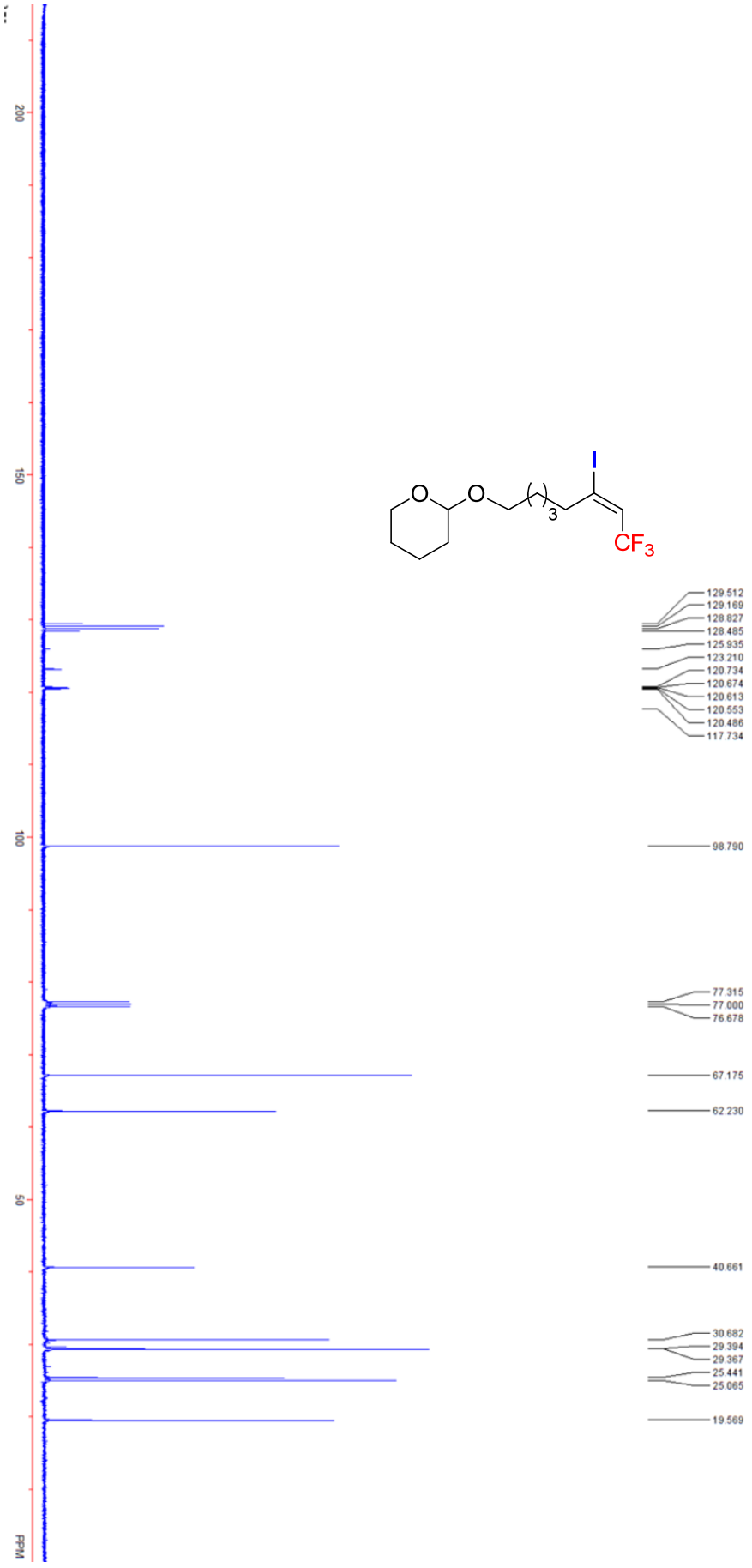
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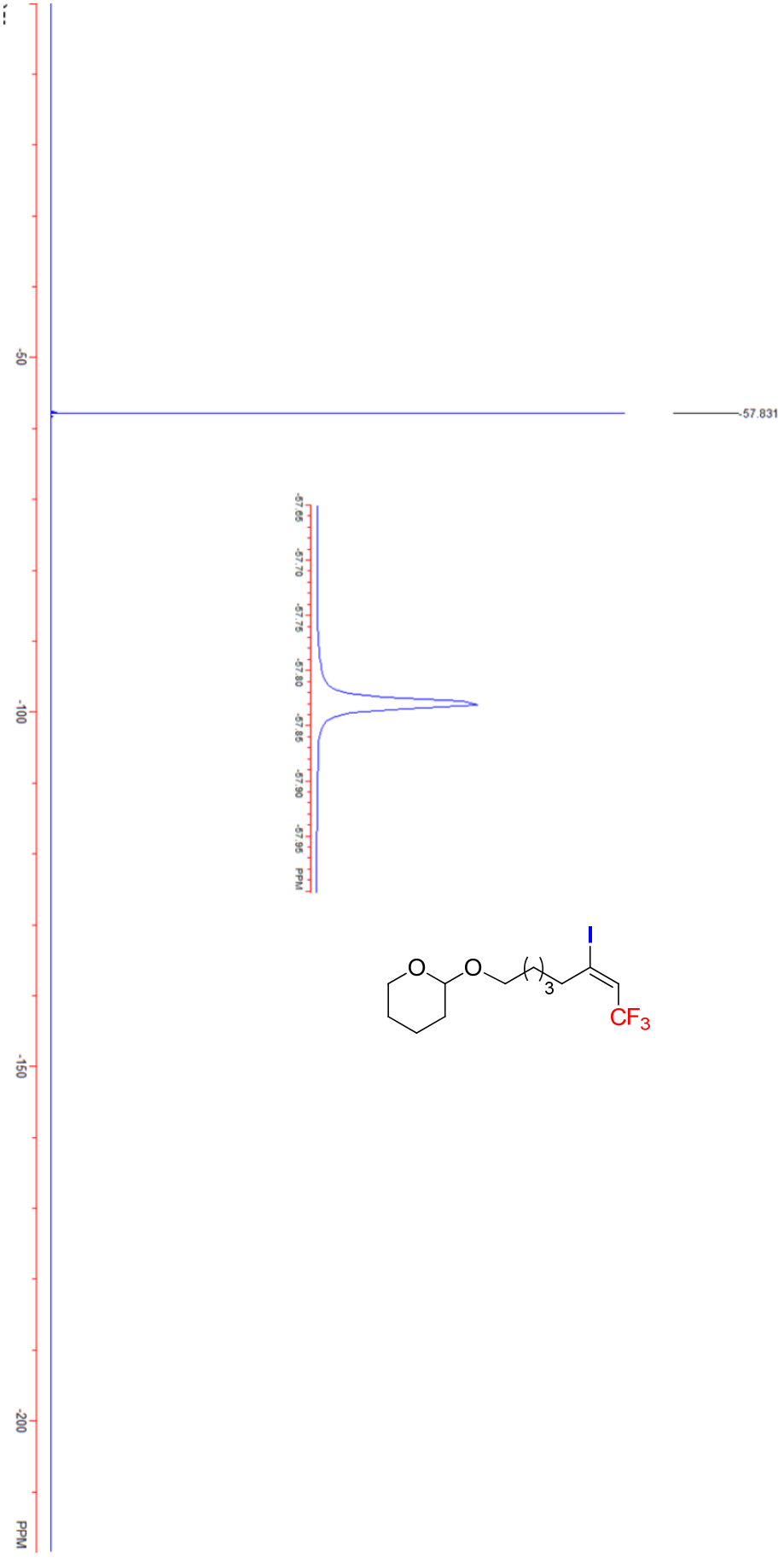
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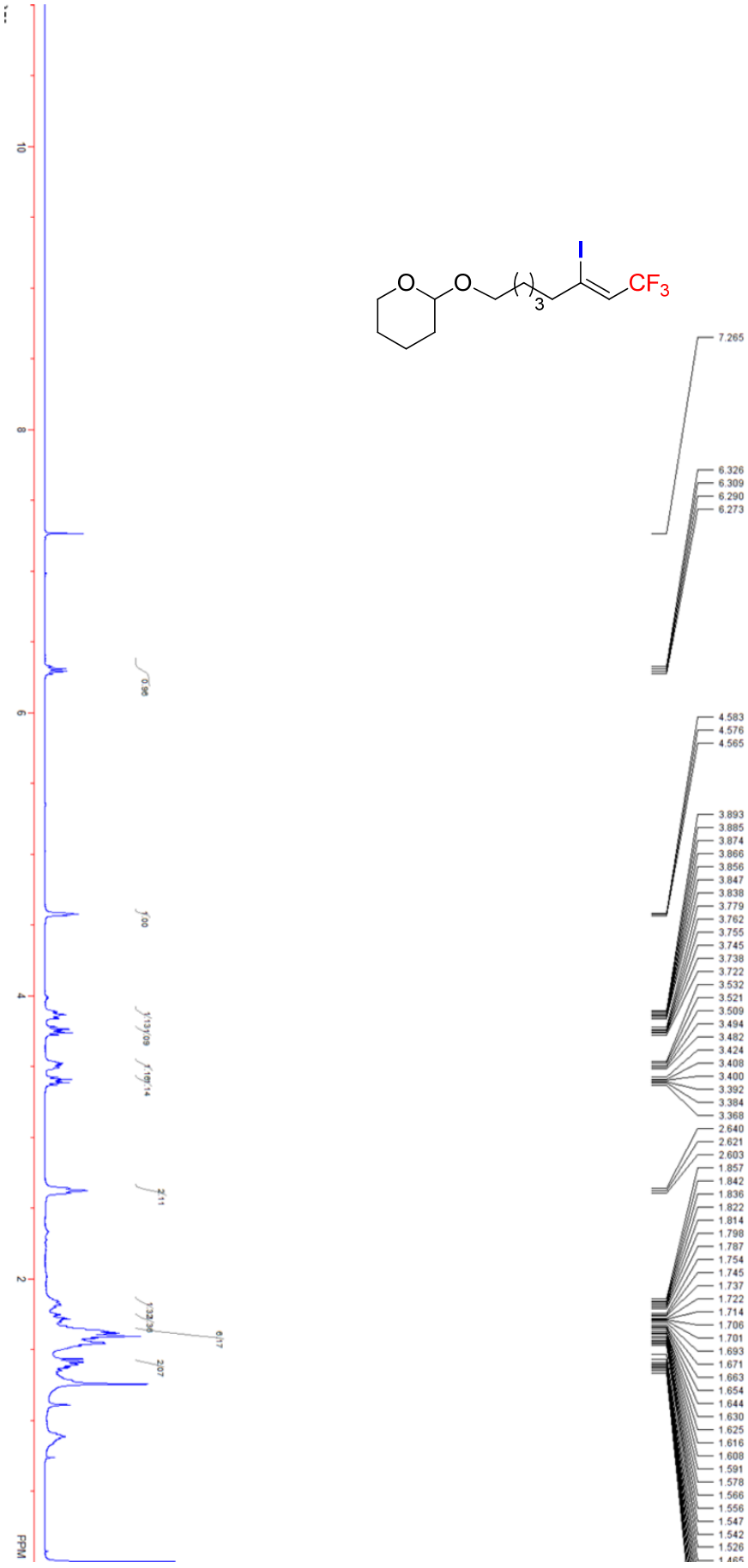
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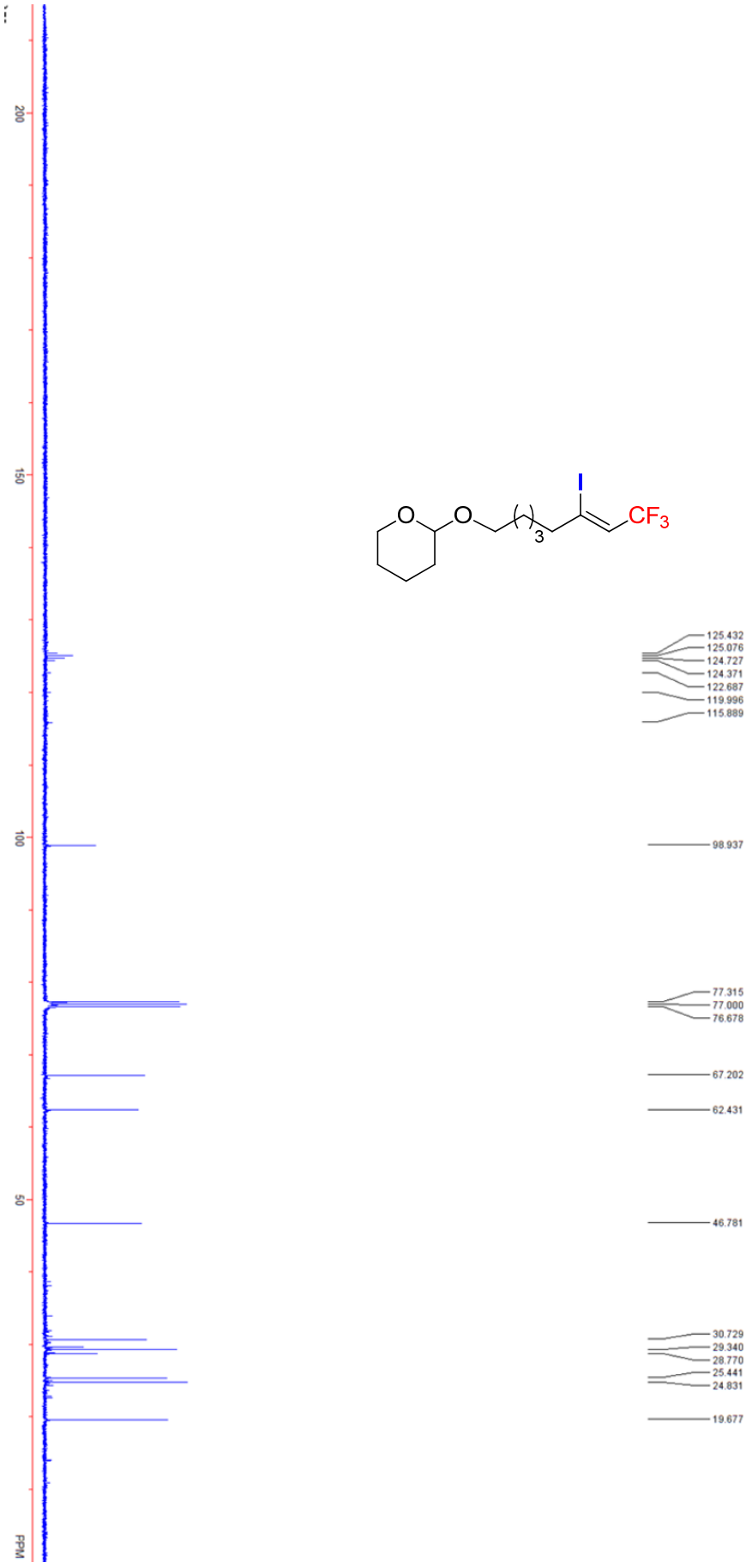
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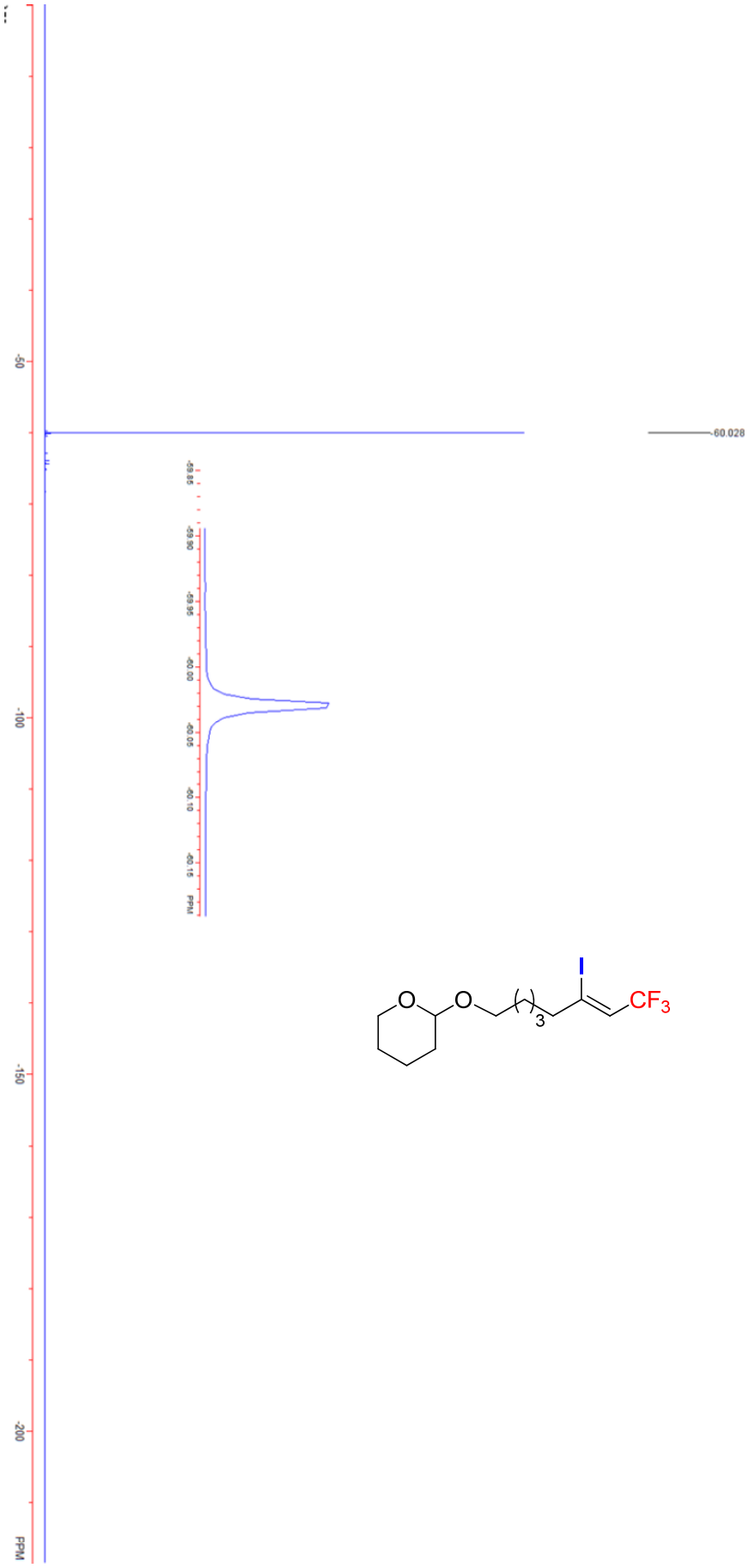
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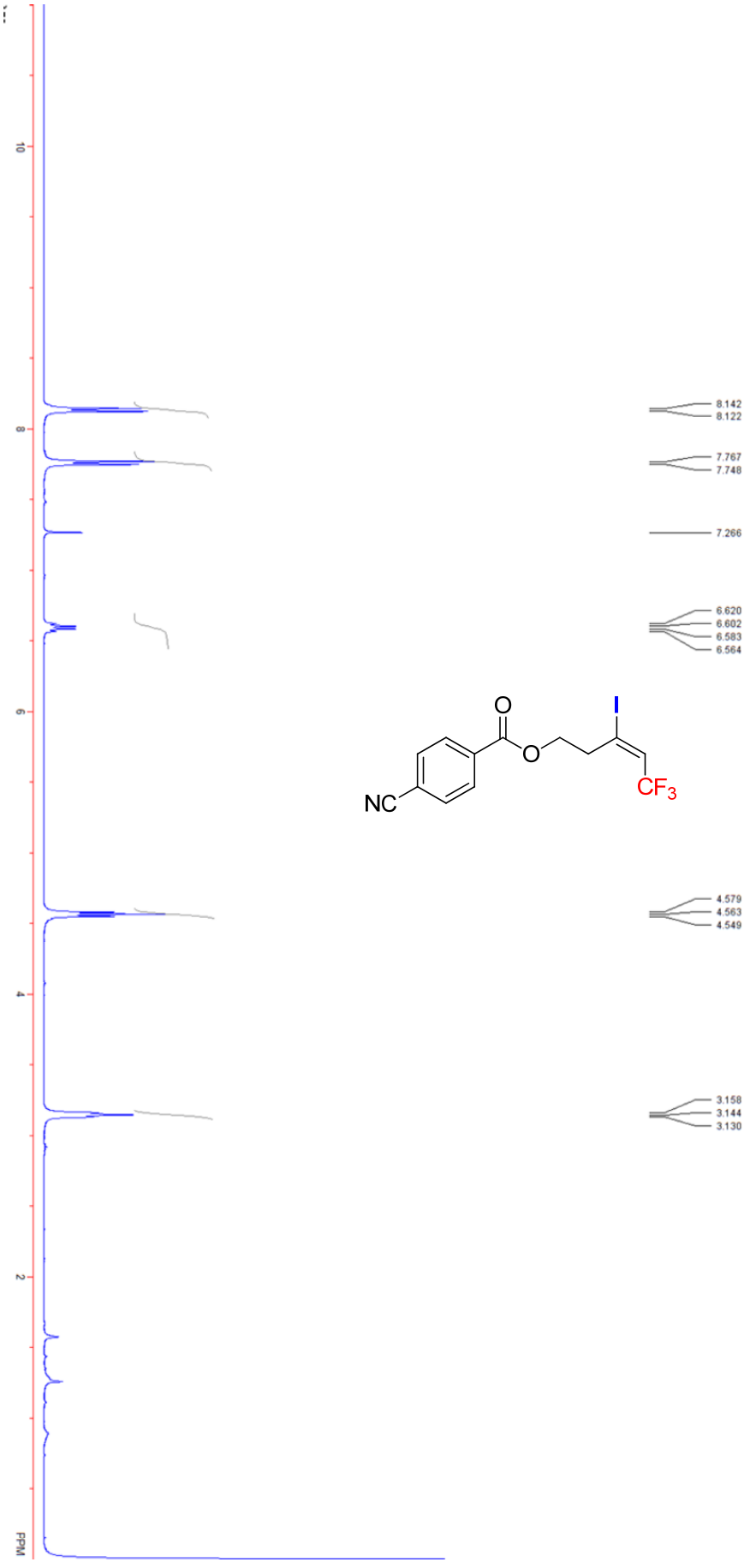
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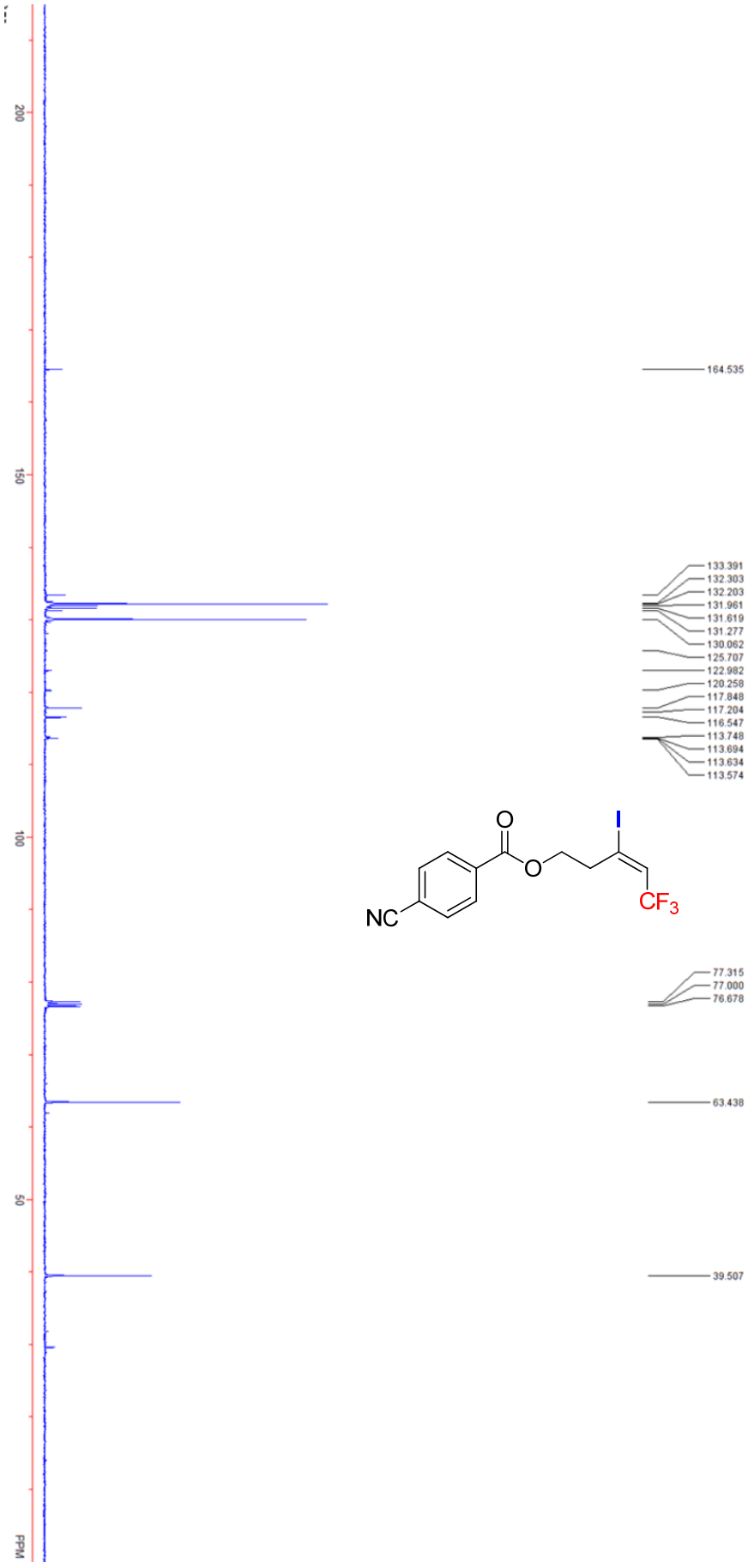
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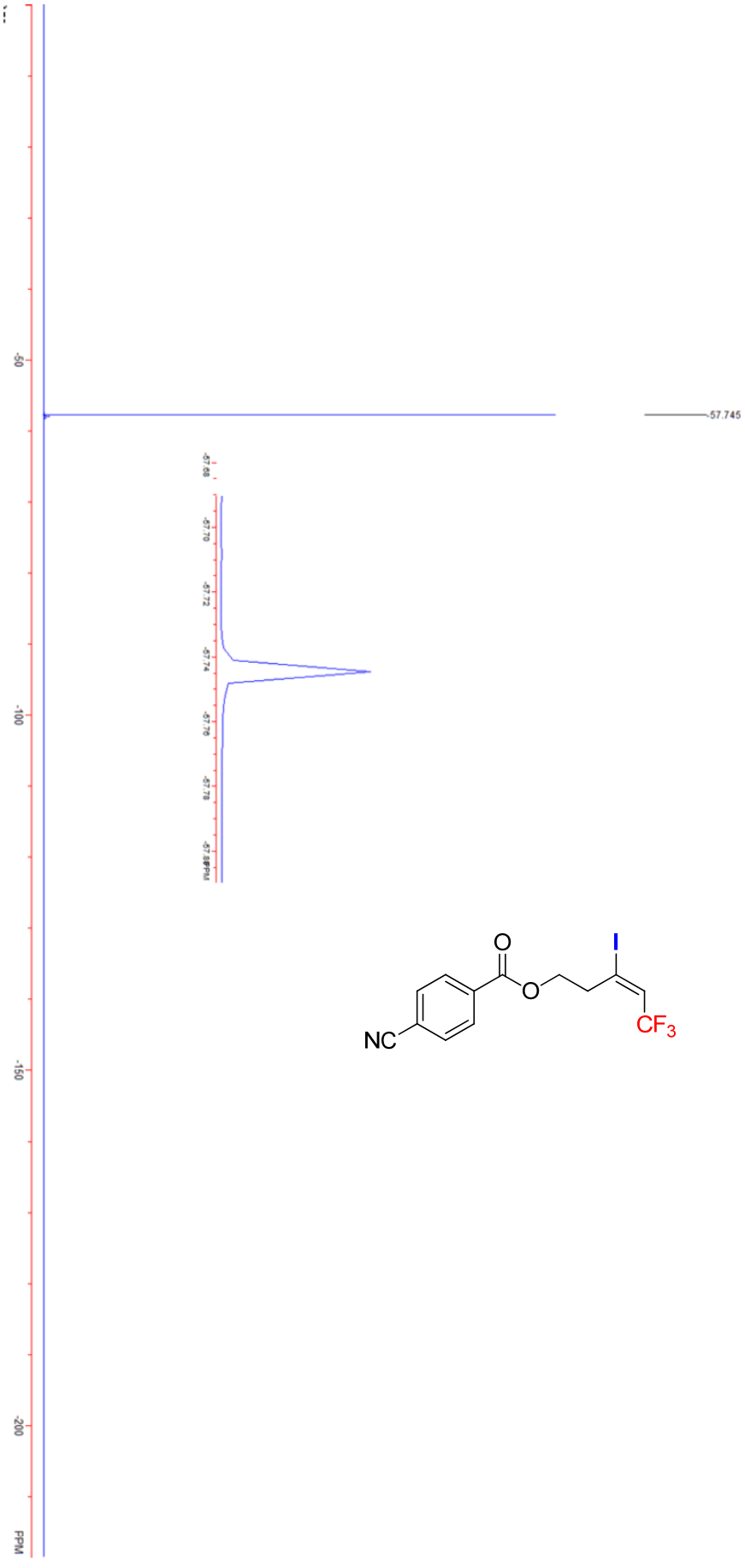
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O
O
I
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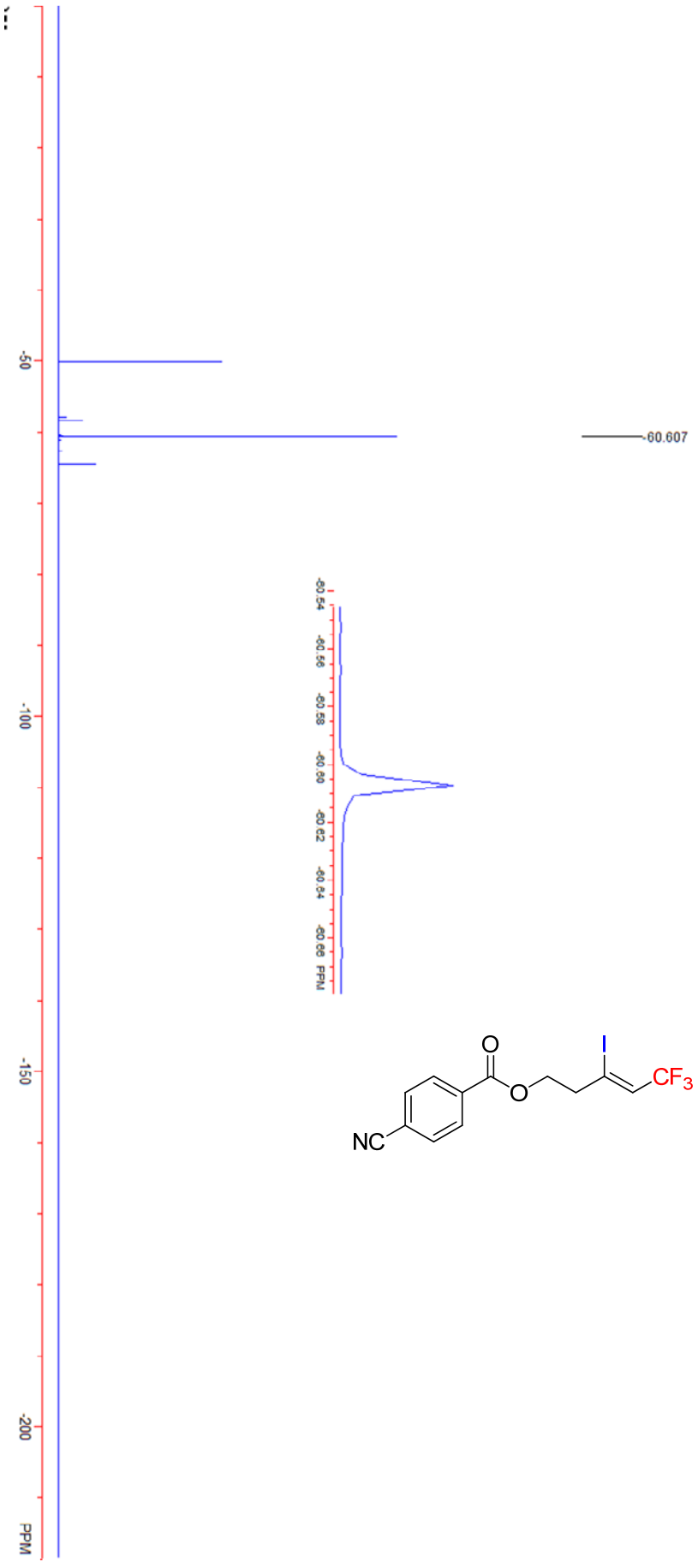
CF3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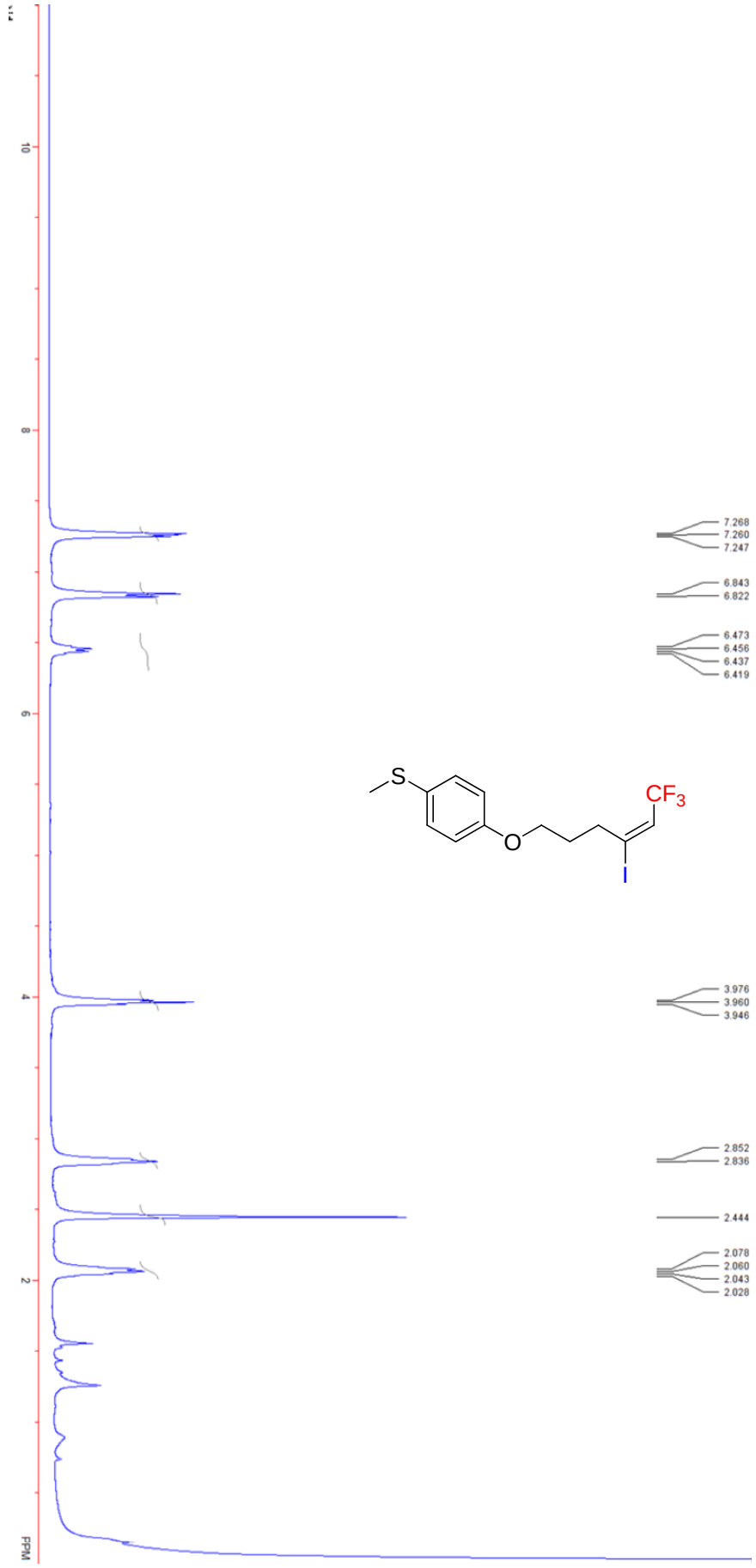
CF3
NC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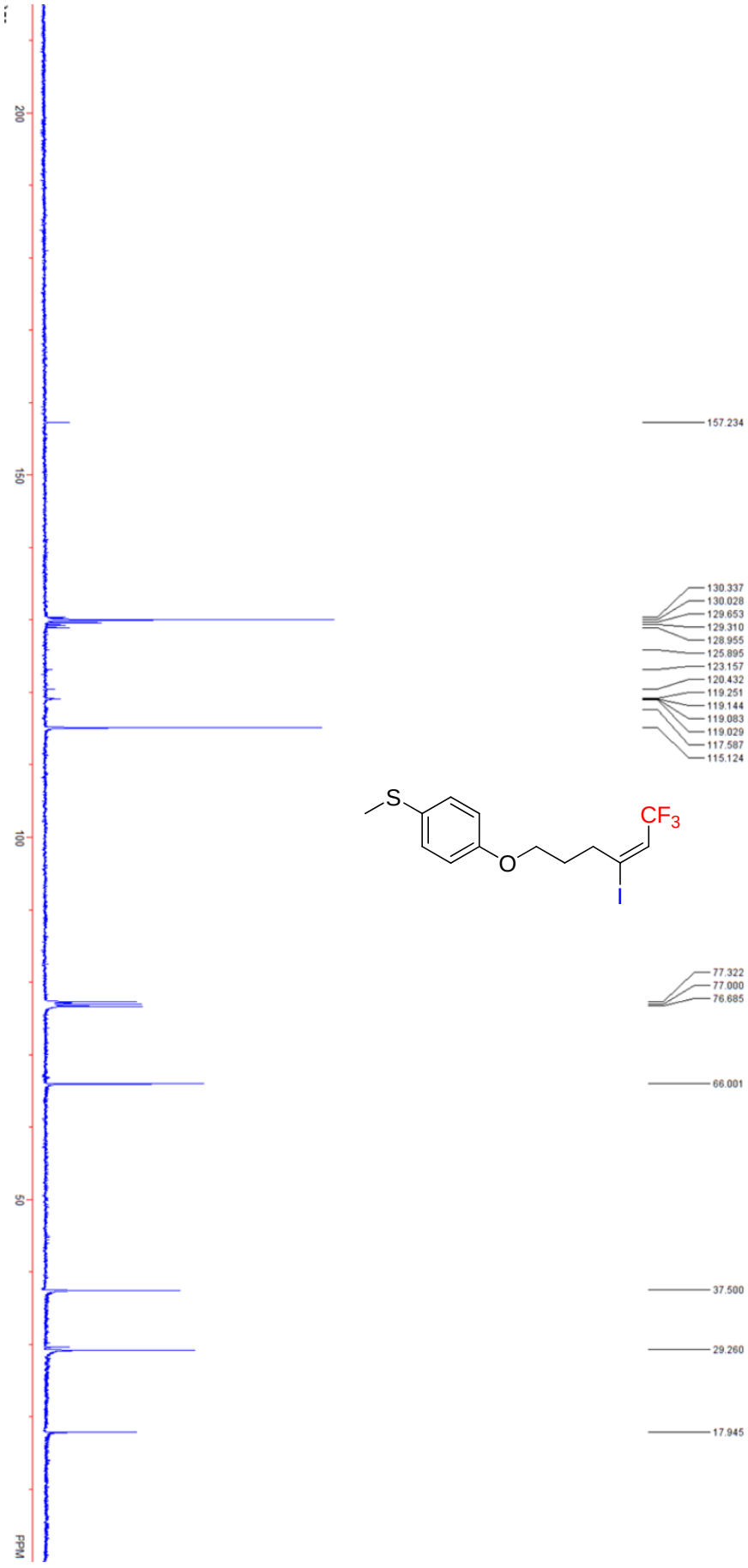
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CF3
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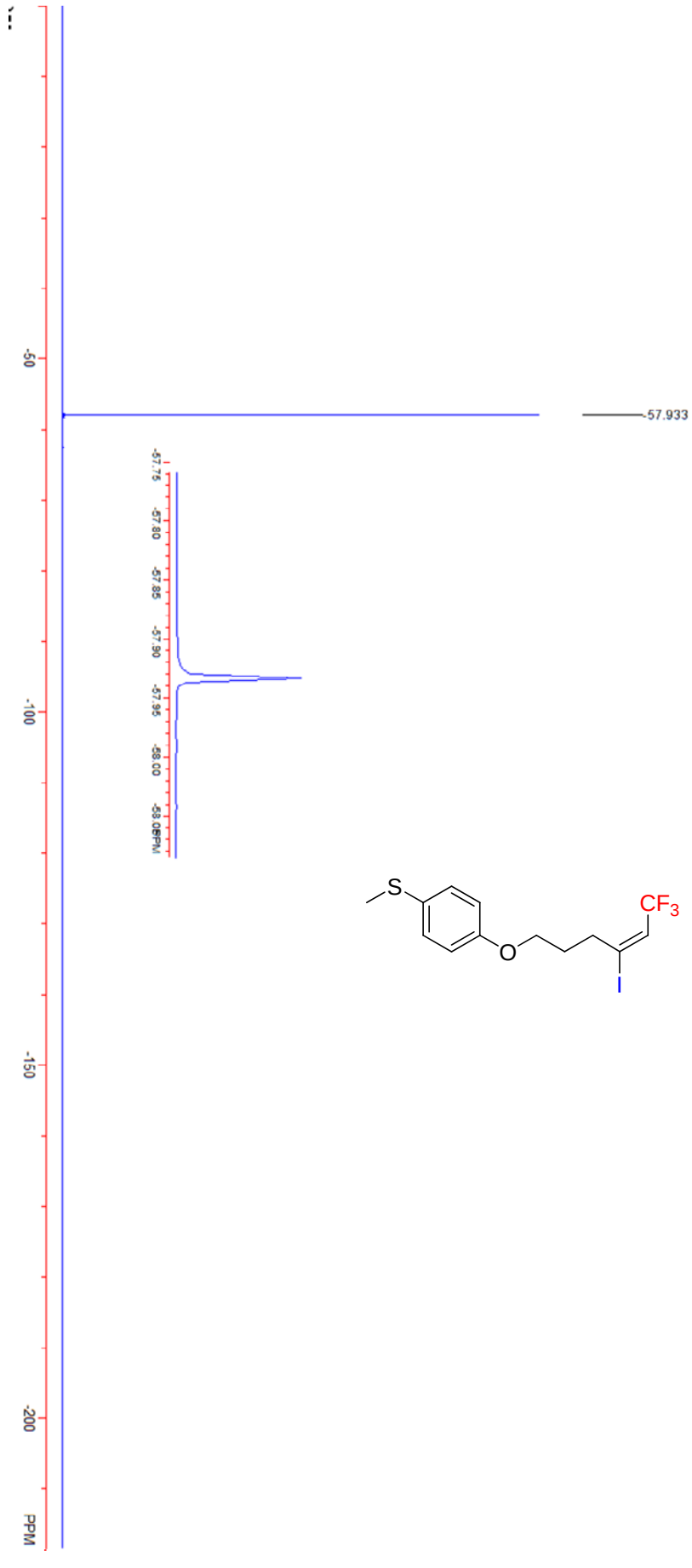
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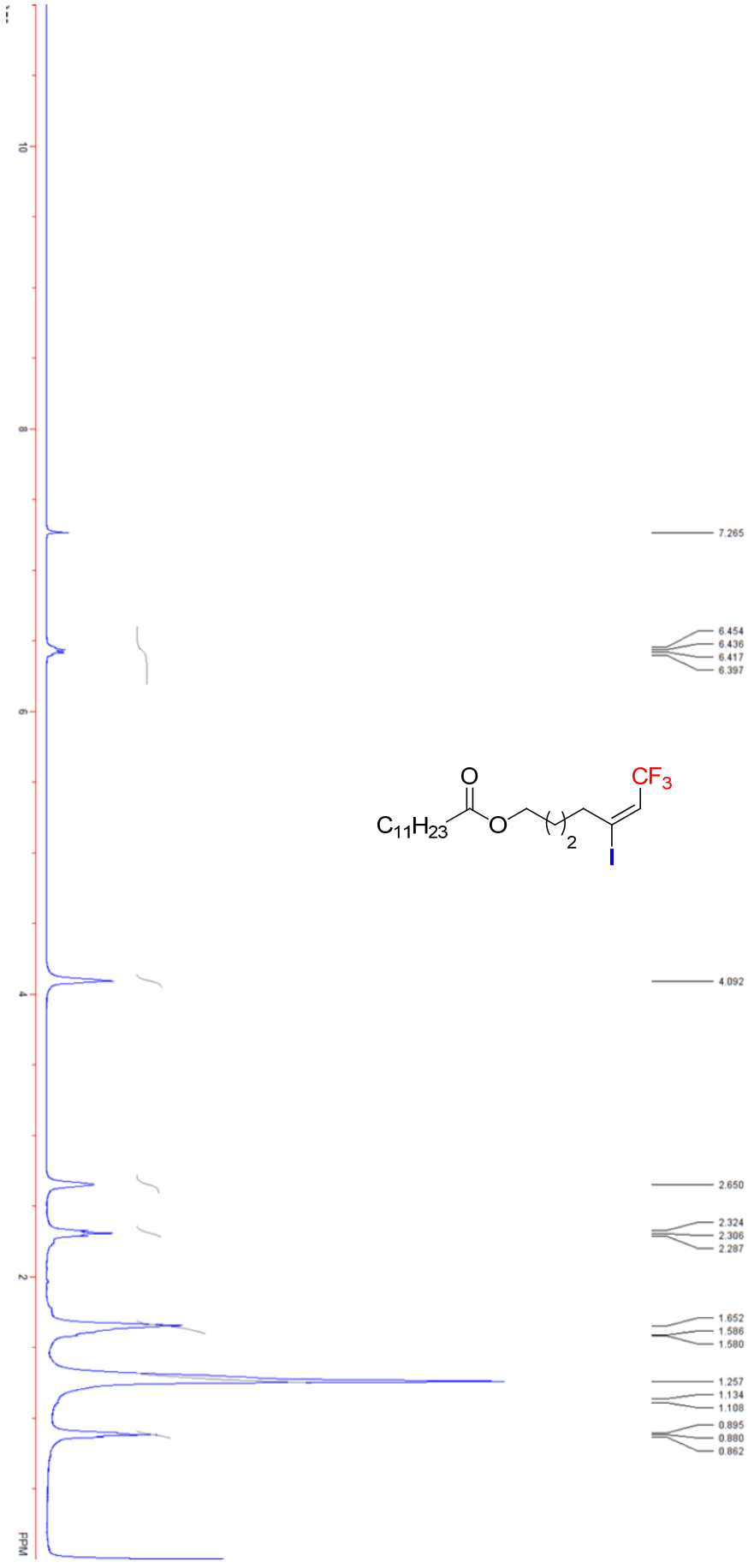
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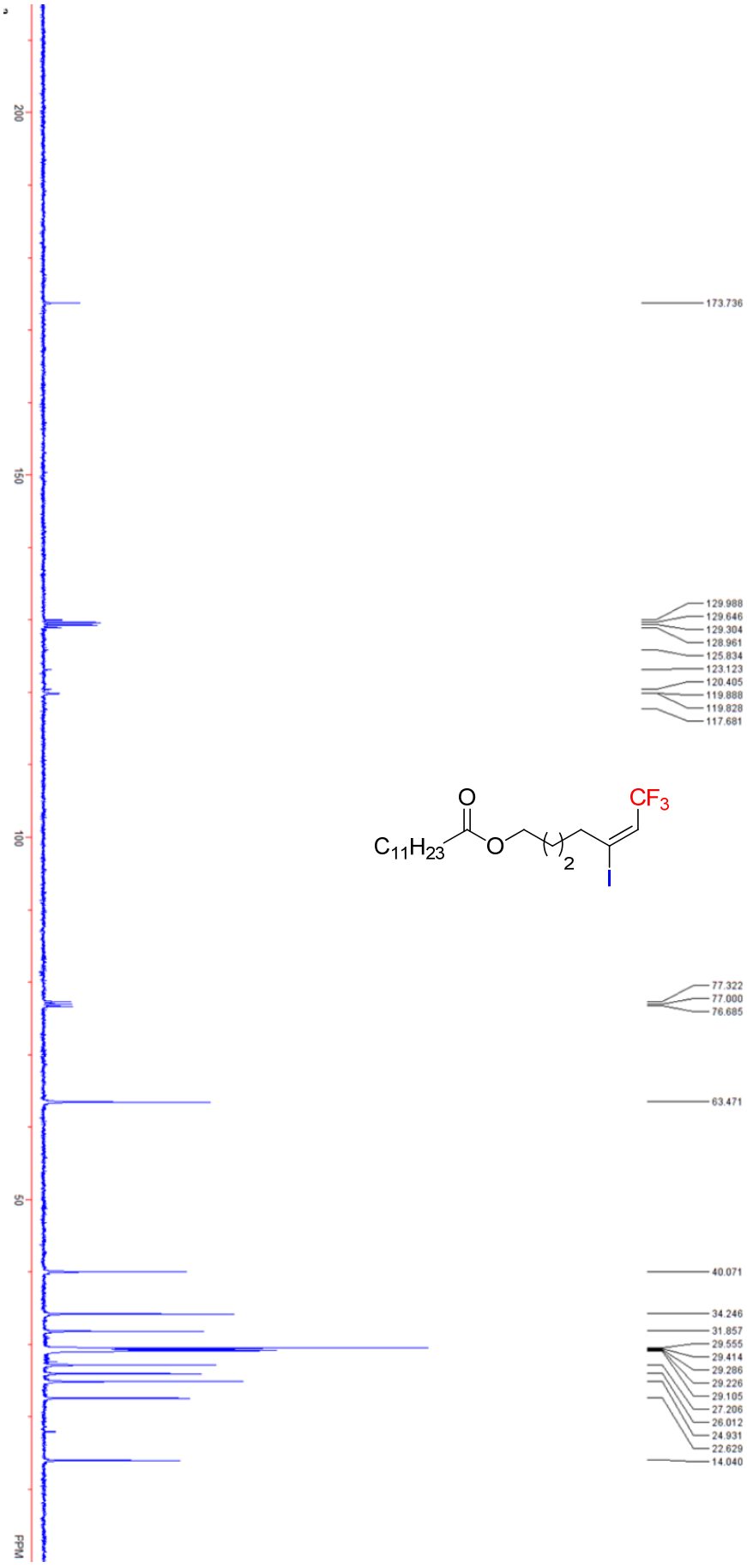
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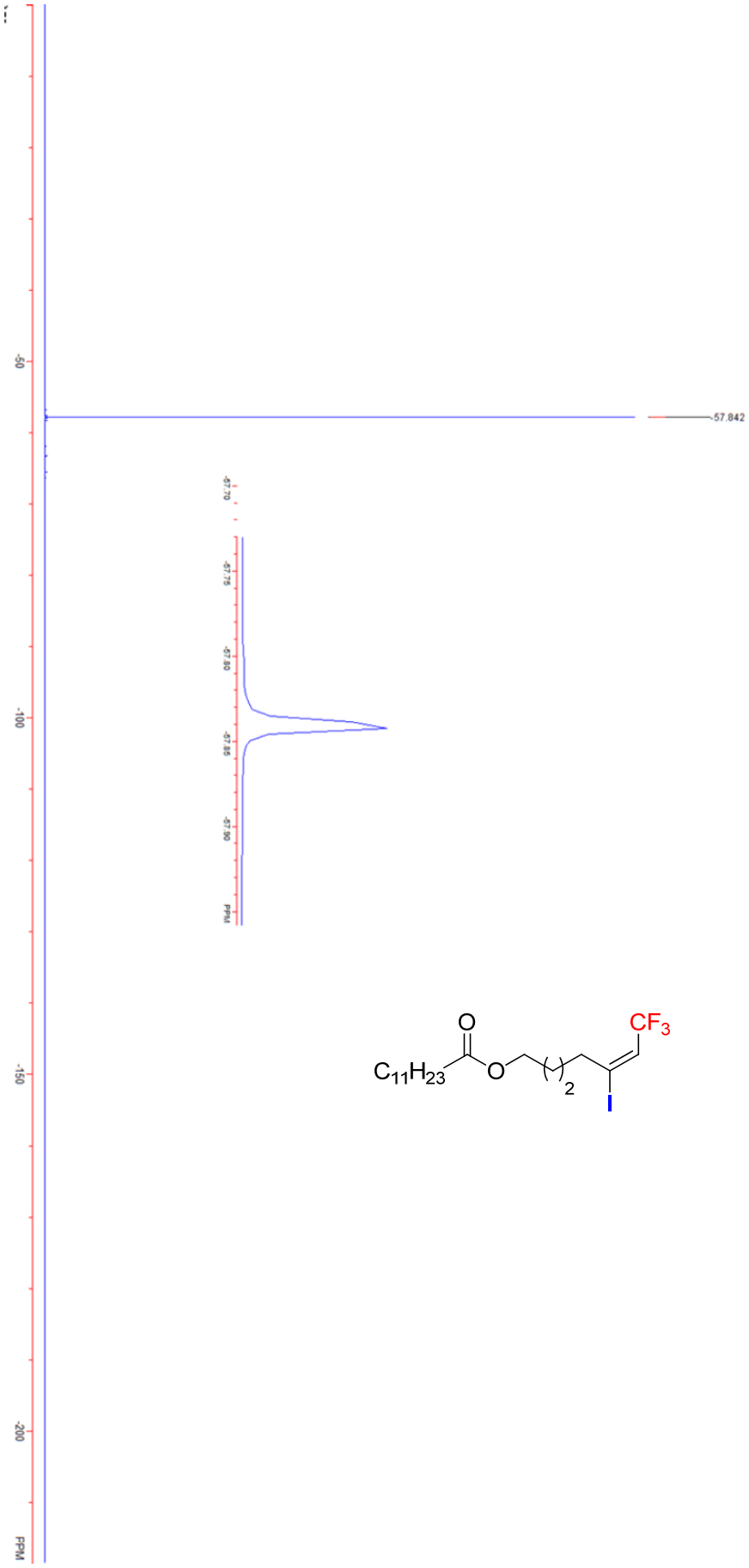
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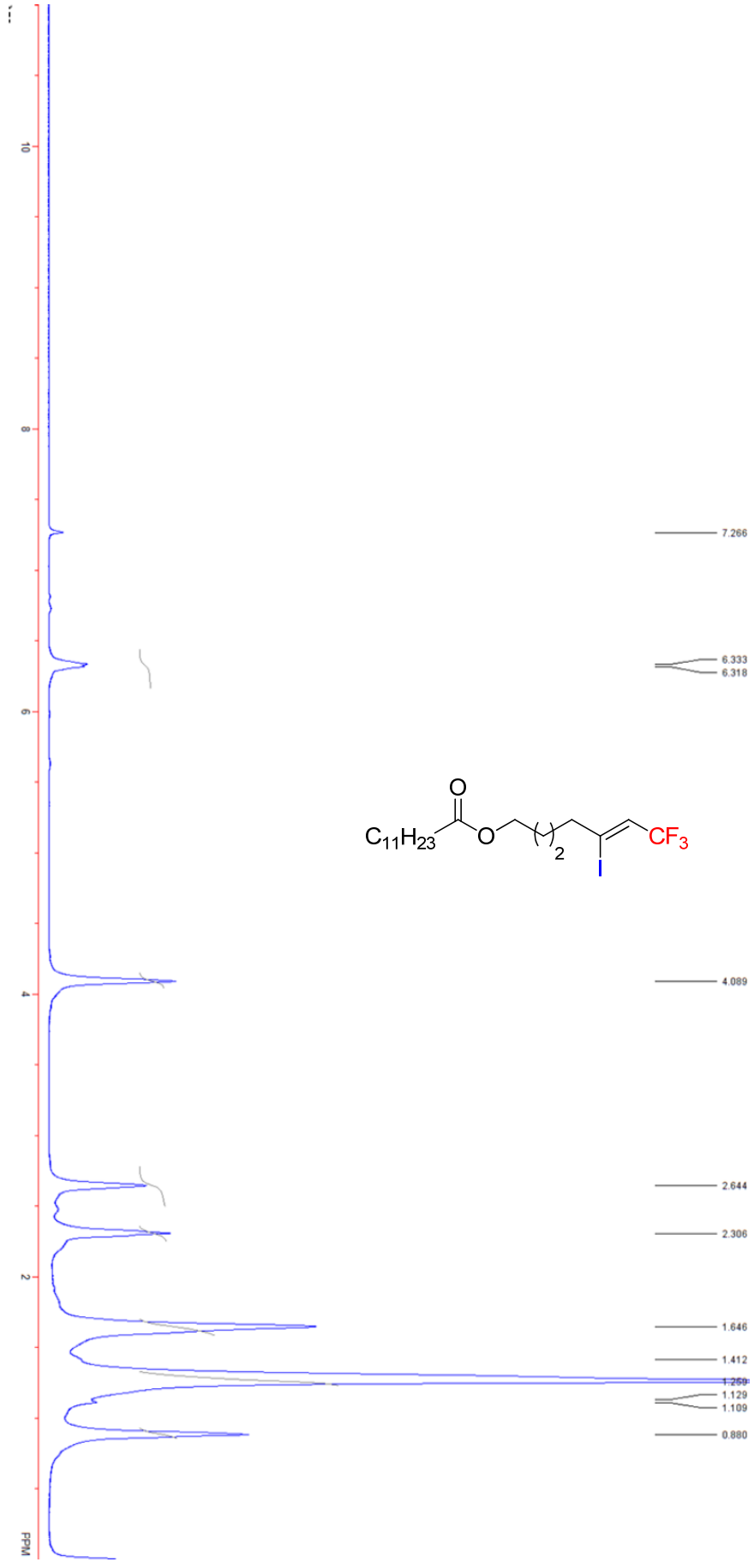
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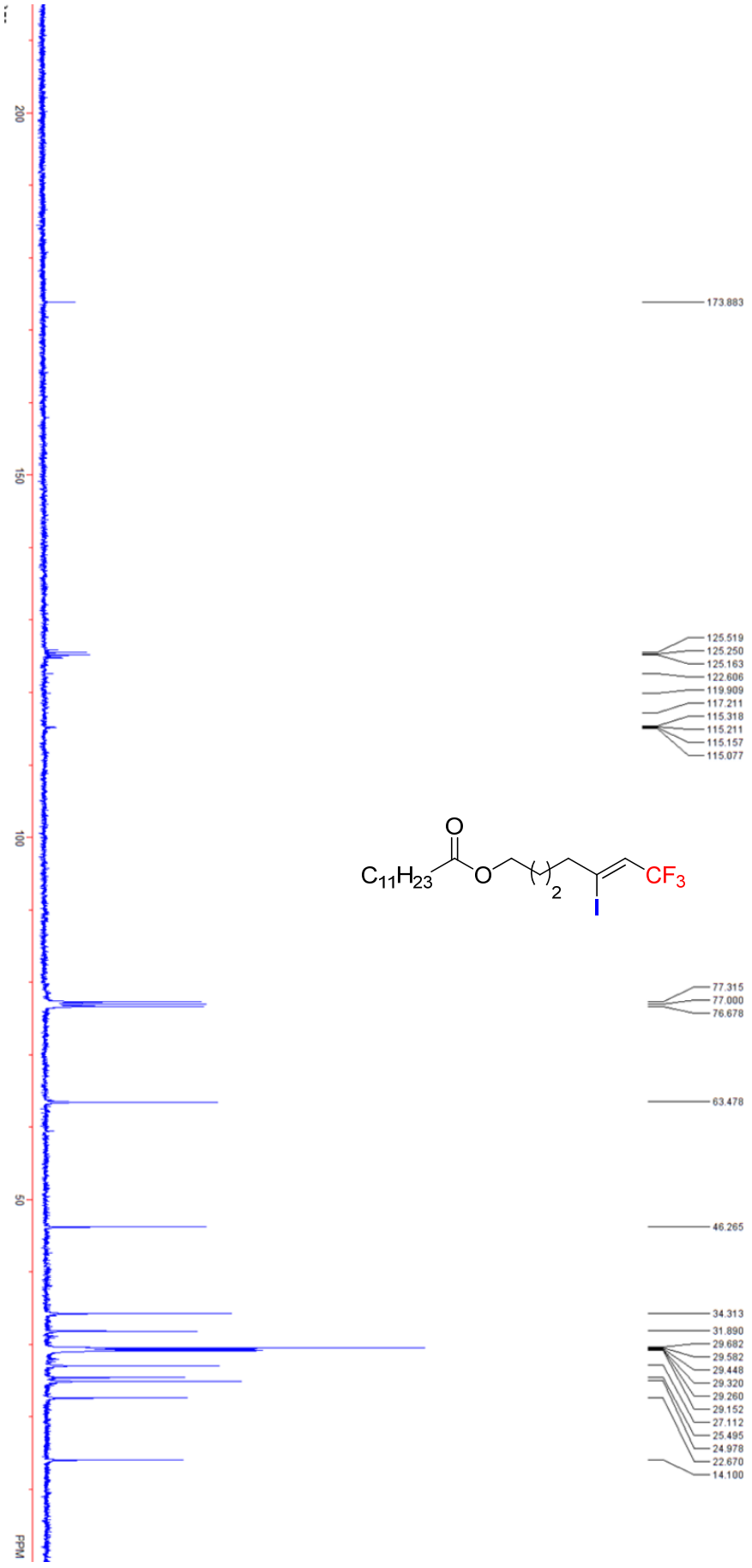
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29.582
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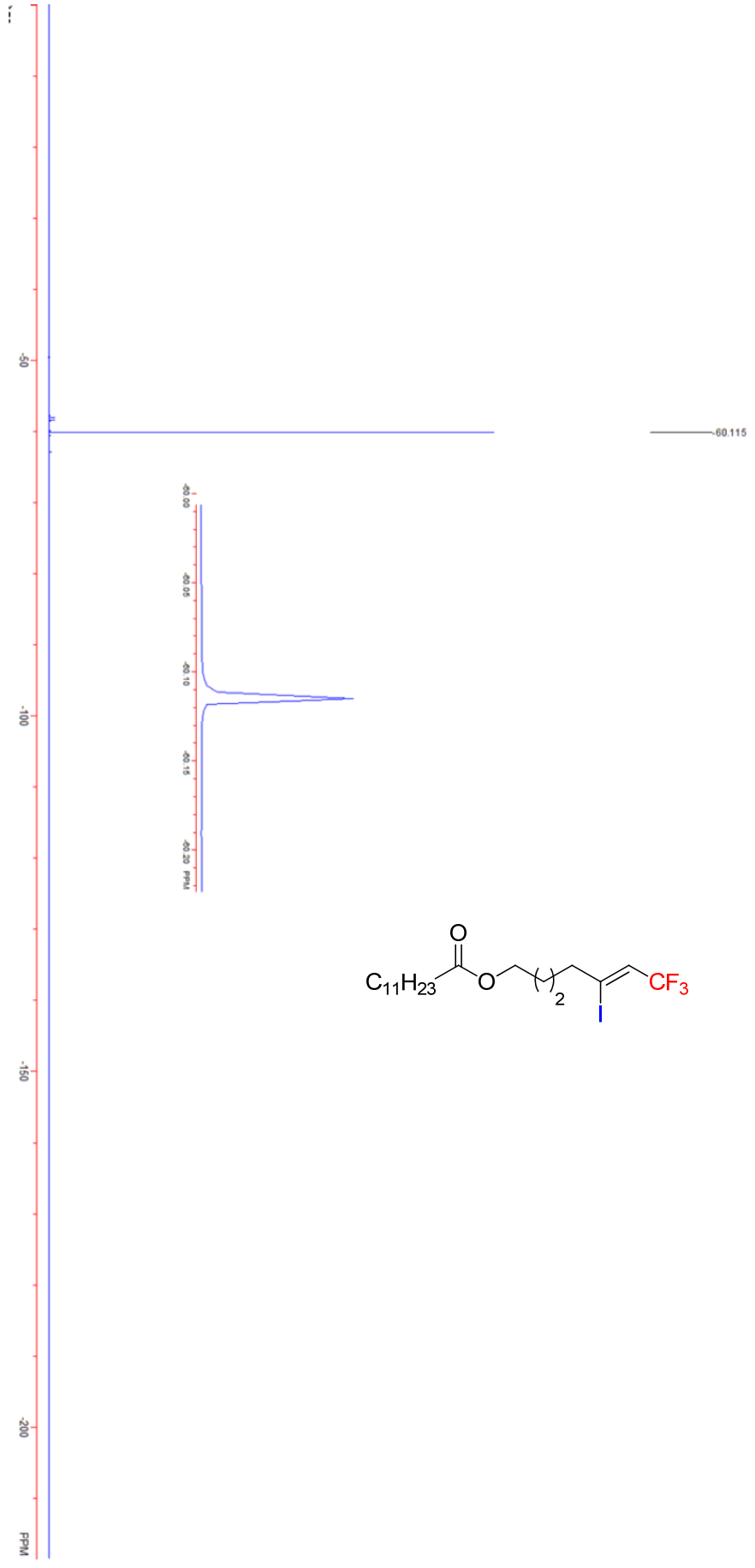
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PPM

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CF3
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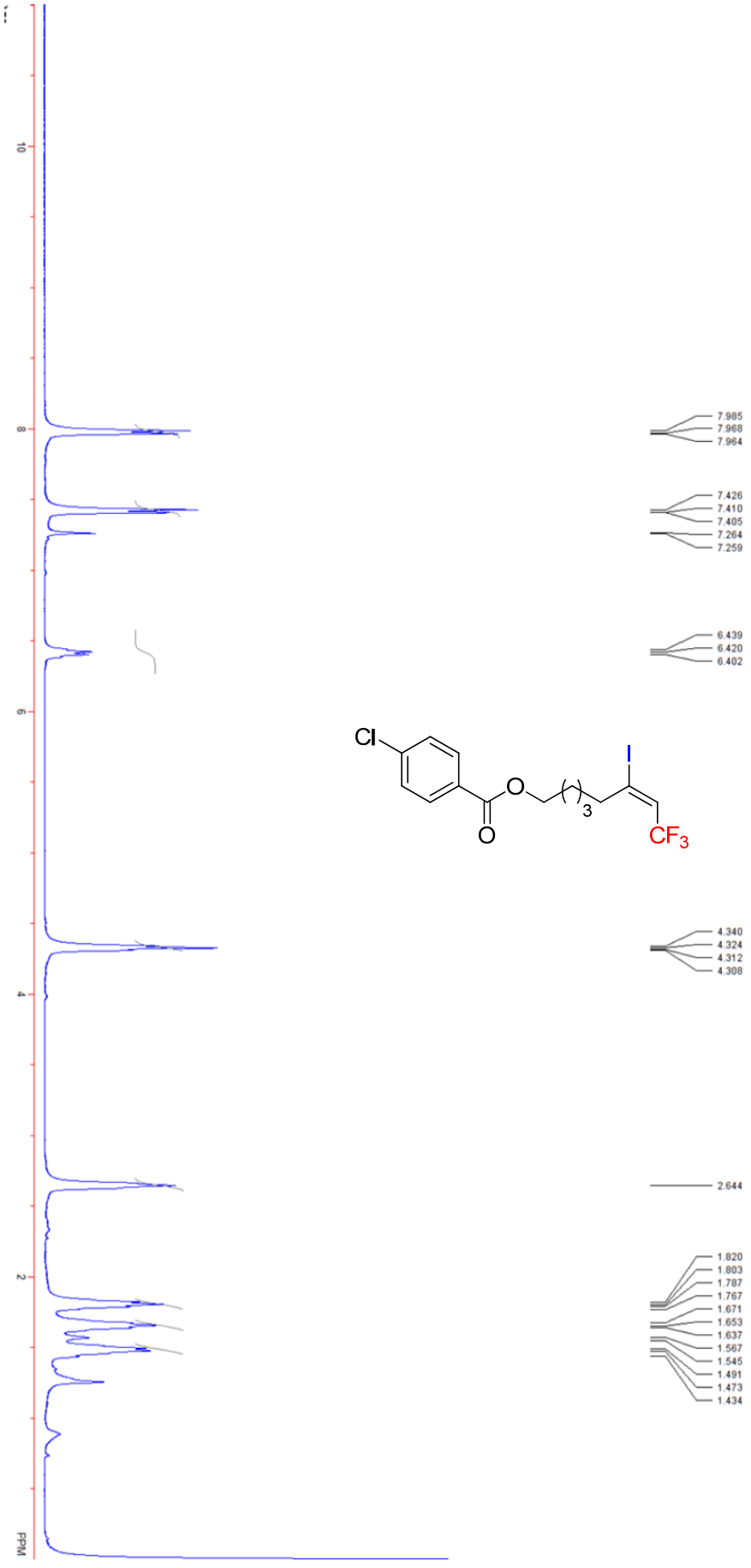
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O
I
3
CF3
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4.324
4.312
4.308
2.644
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1.653
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1.545
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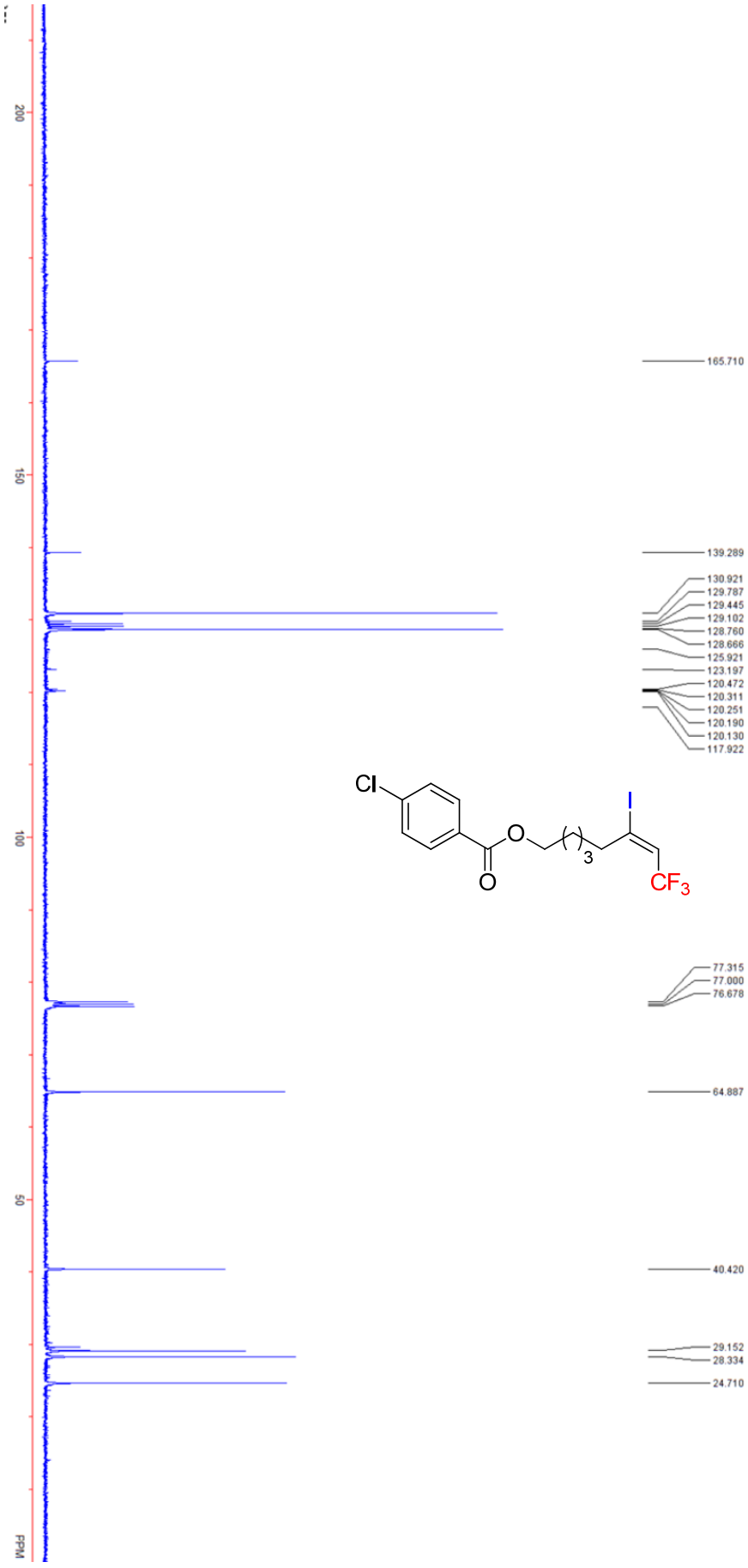
1.473
1.434
PPM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120.130
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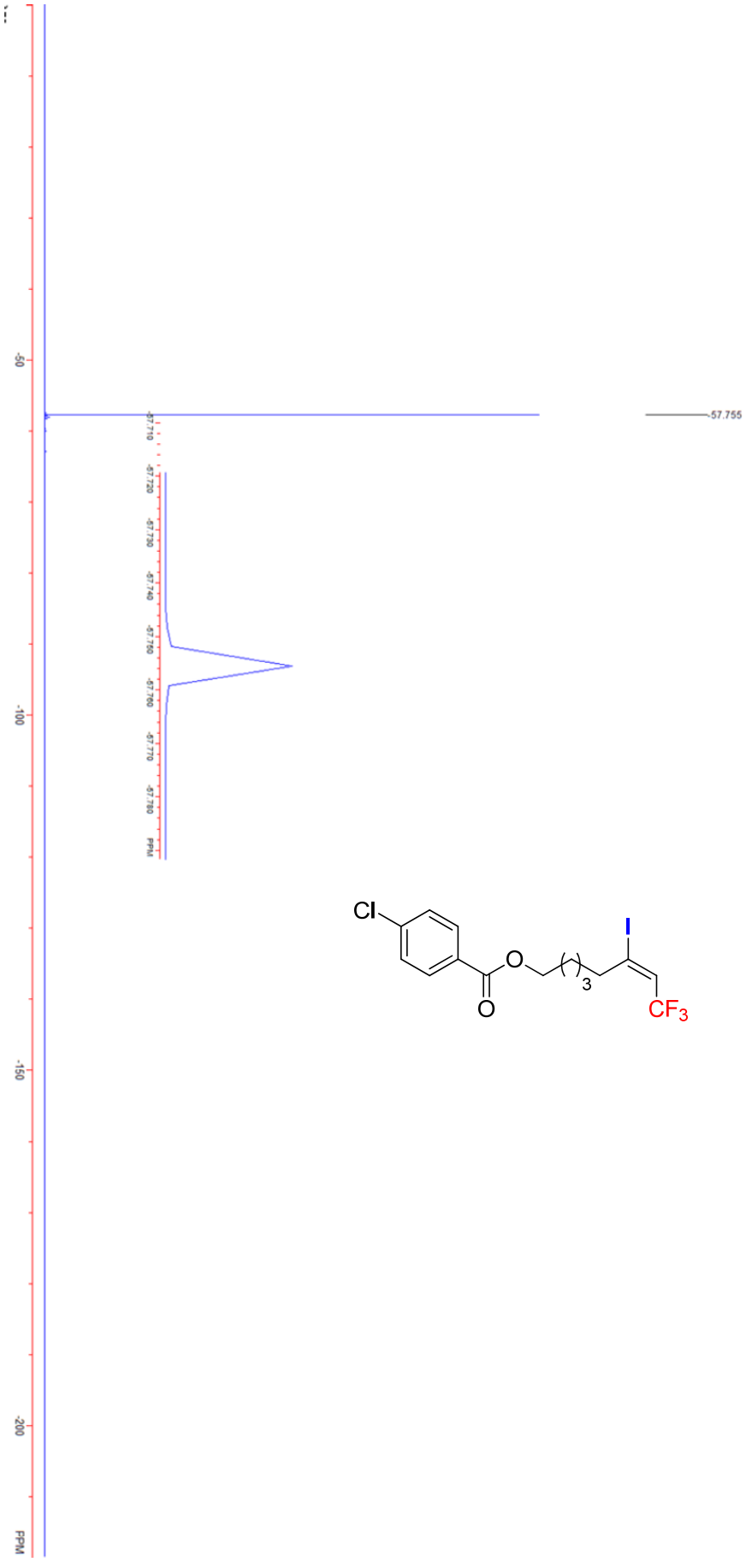
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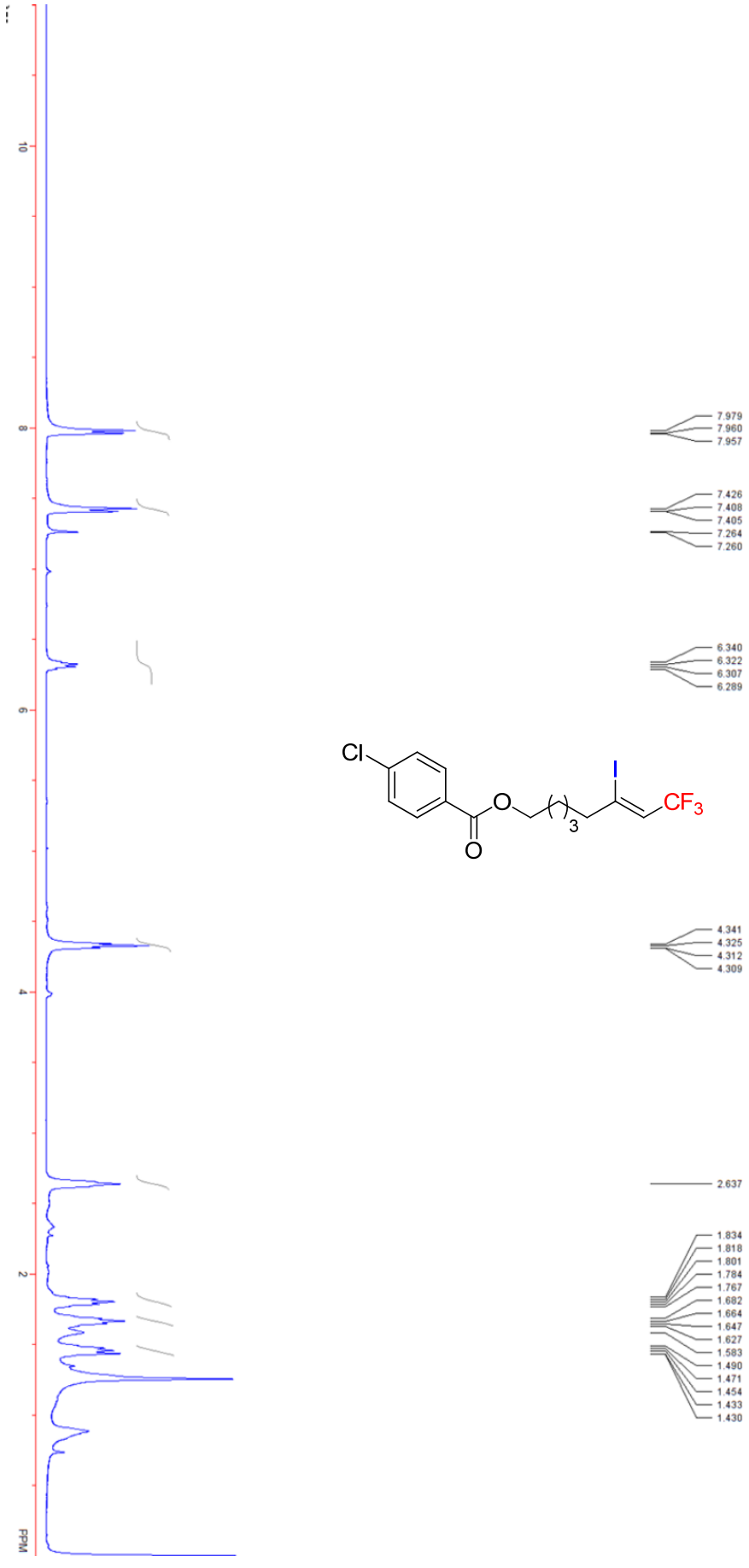
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O
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4.312
4.309
2.637
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1.818
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1.767
1.682
1.664
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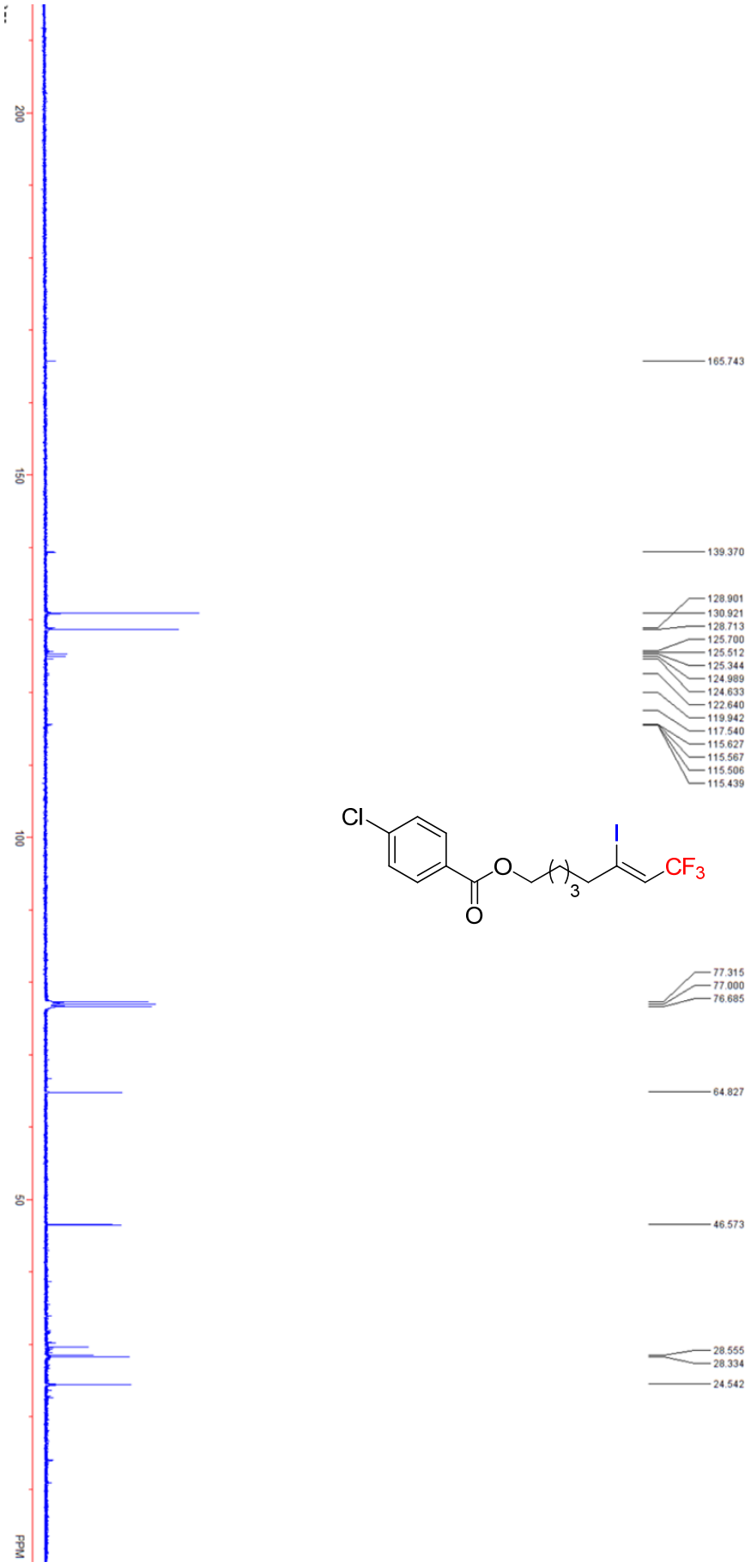
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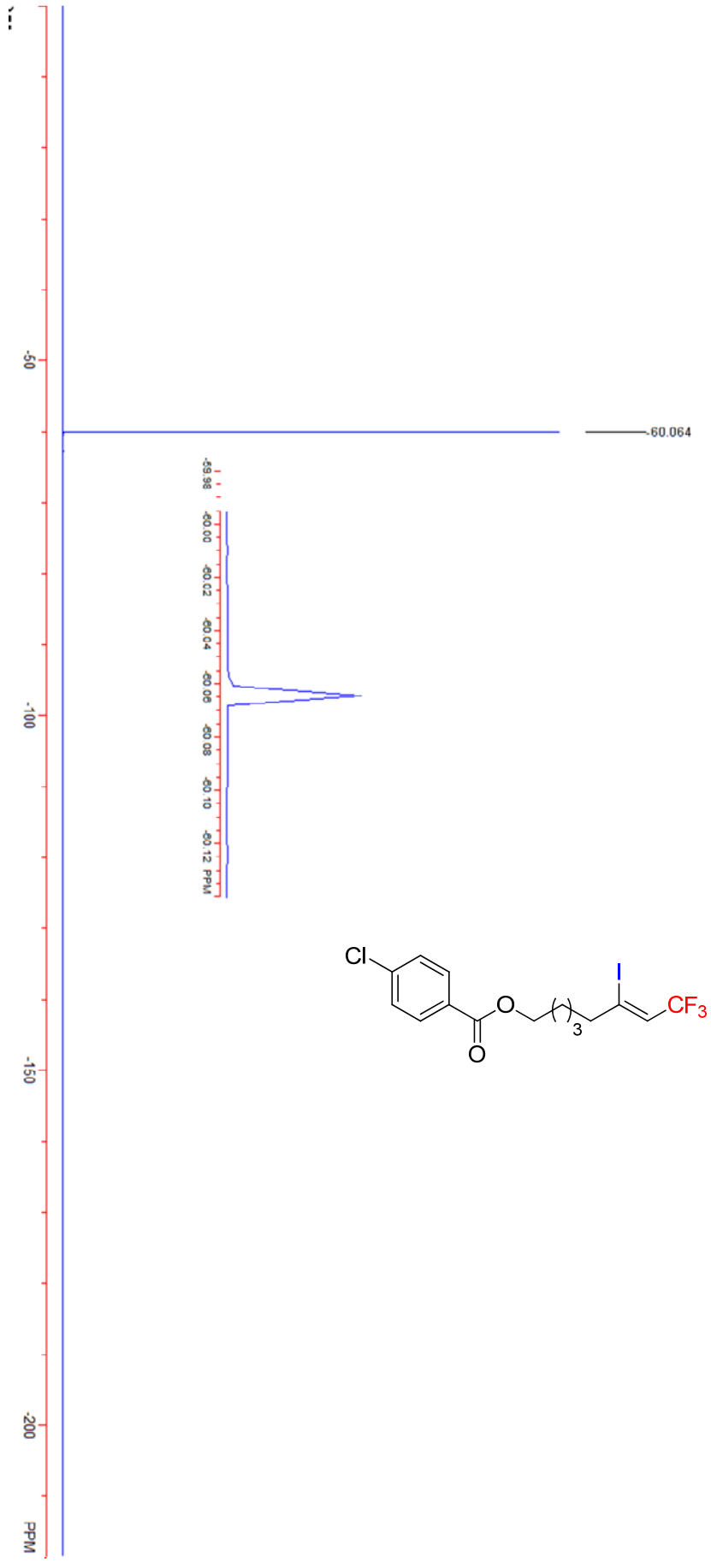
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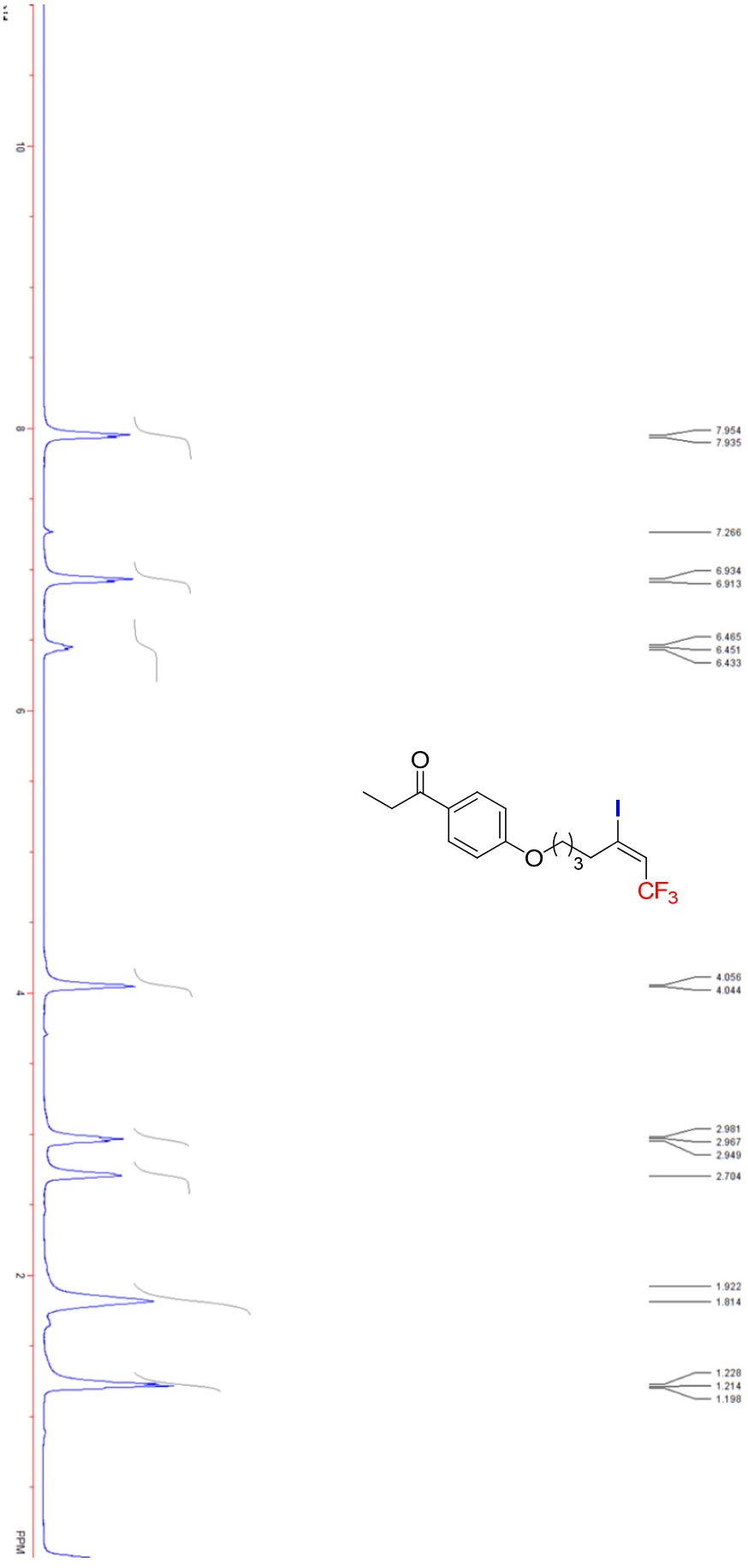
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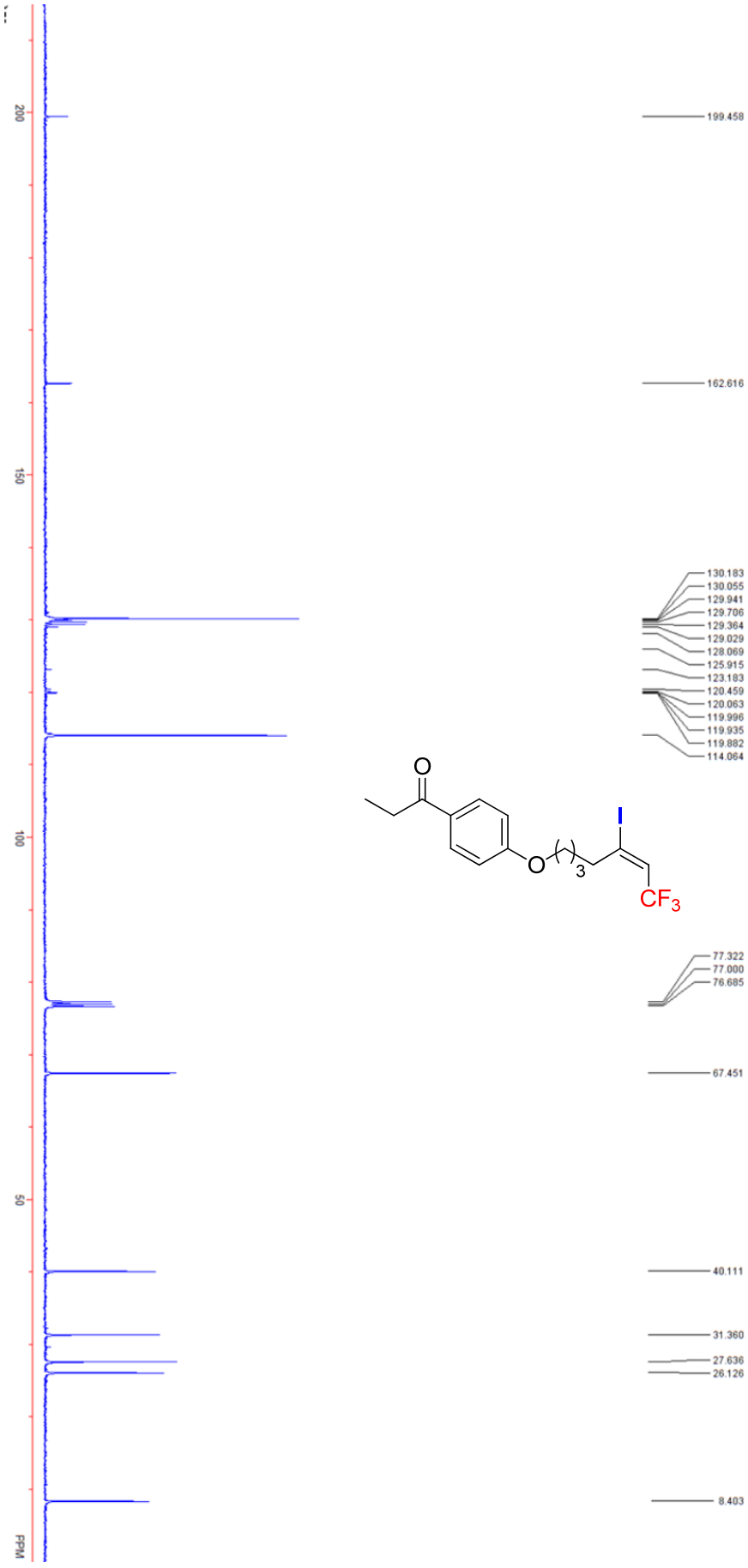
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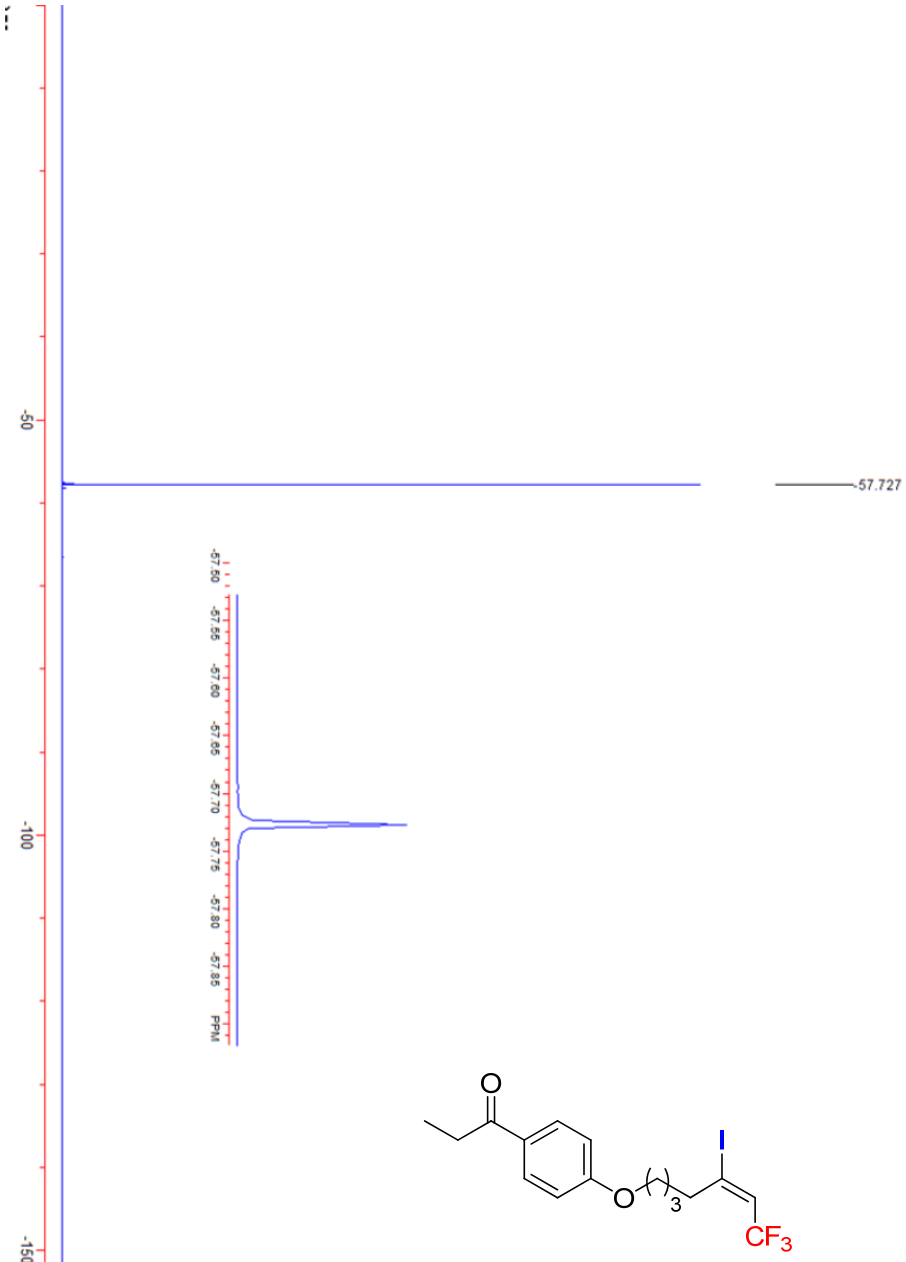
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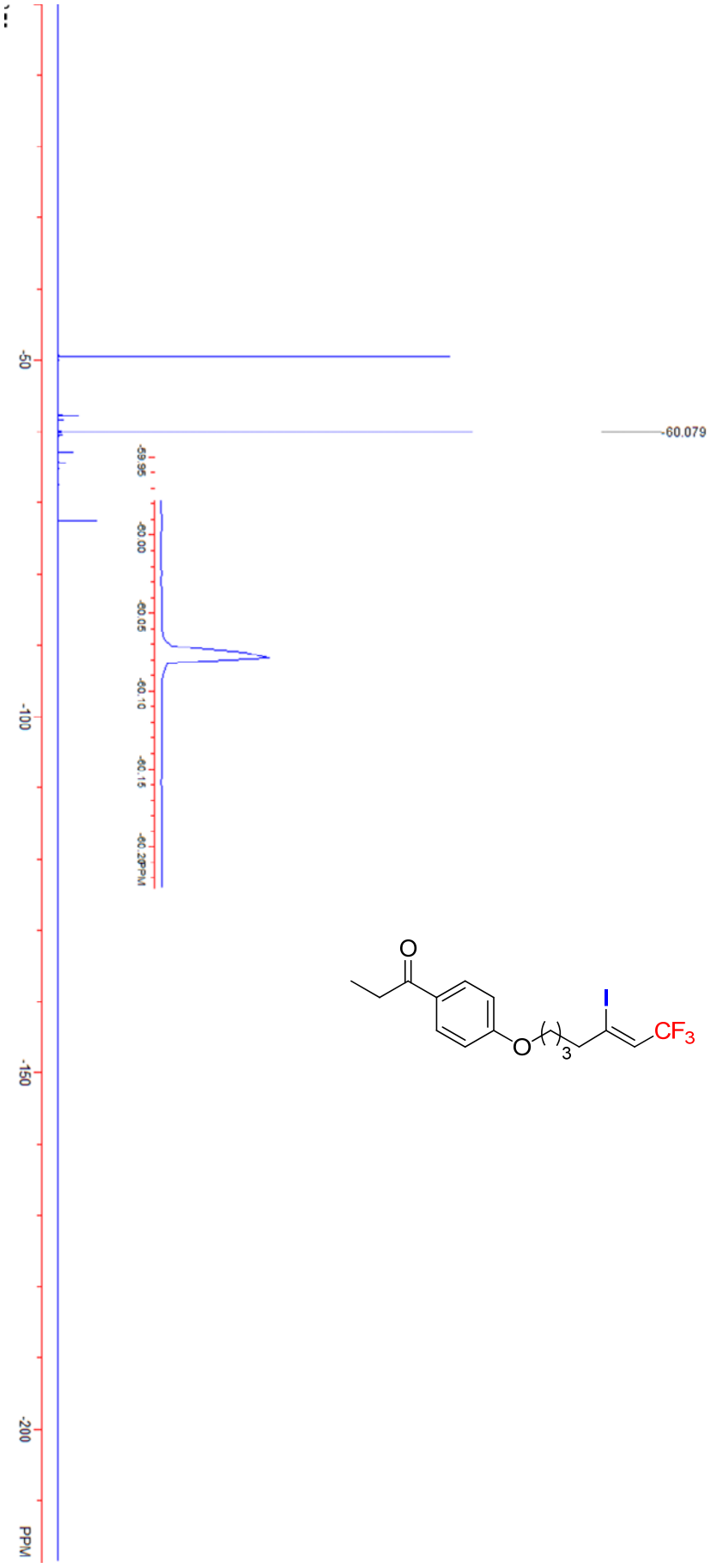
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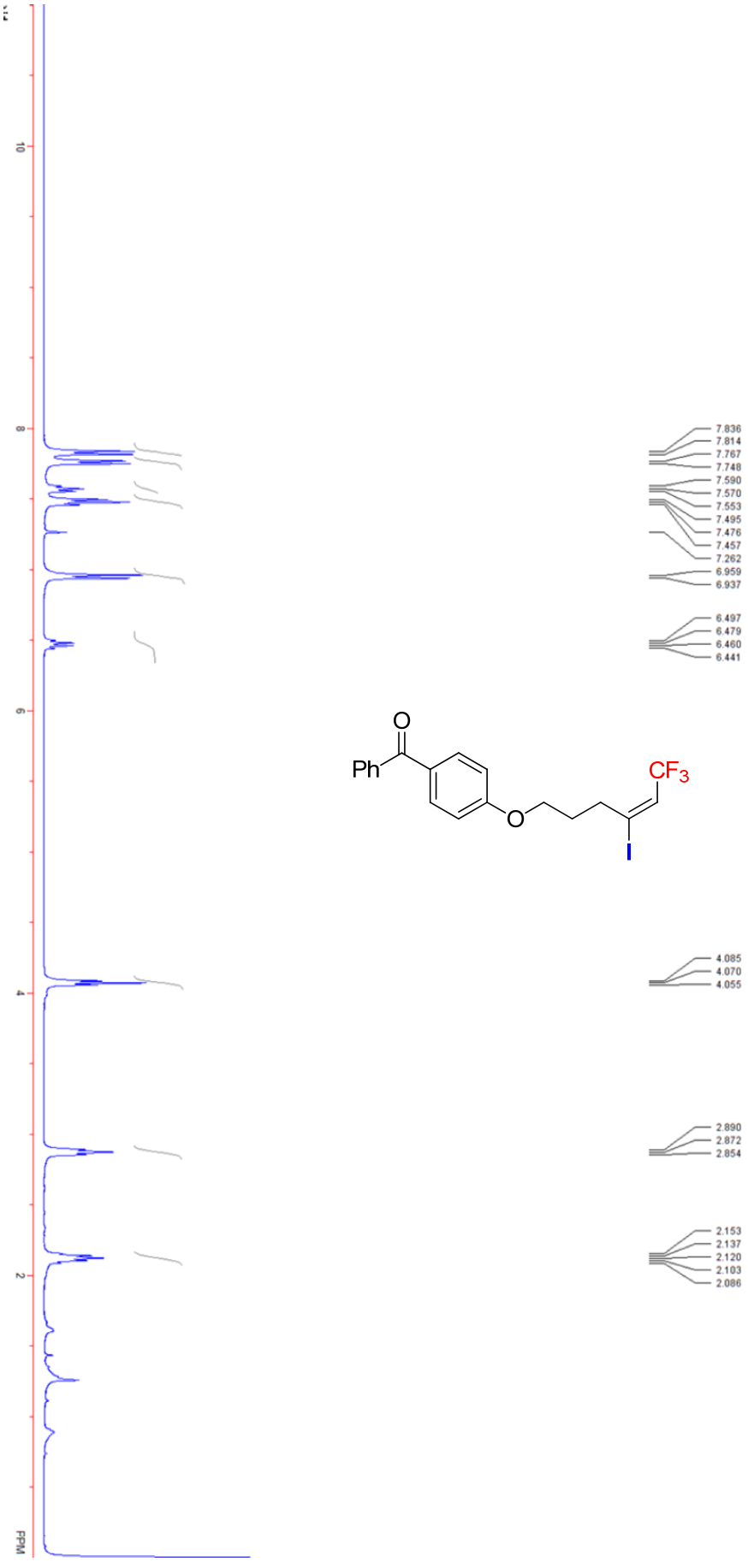
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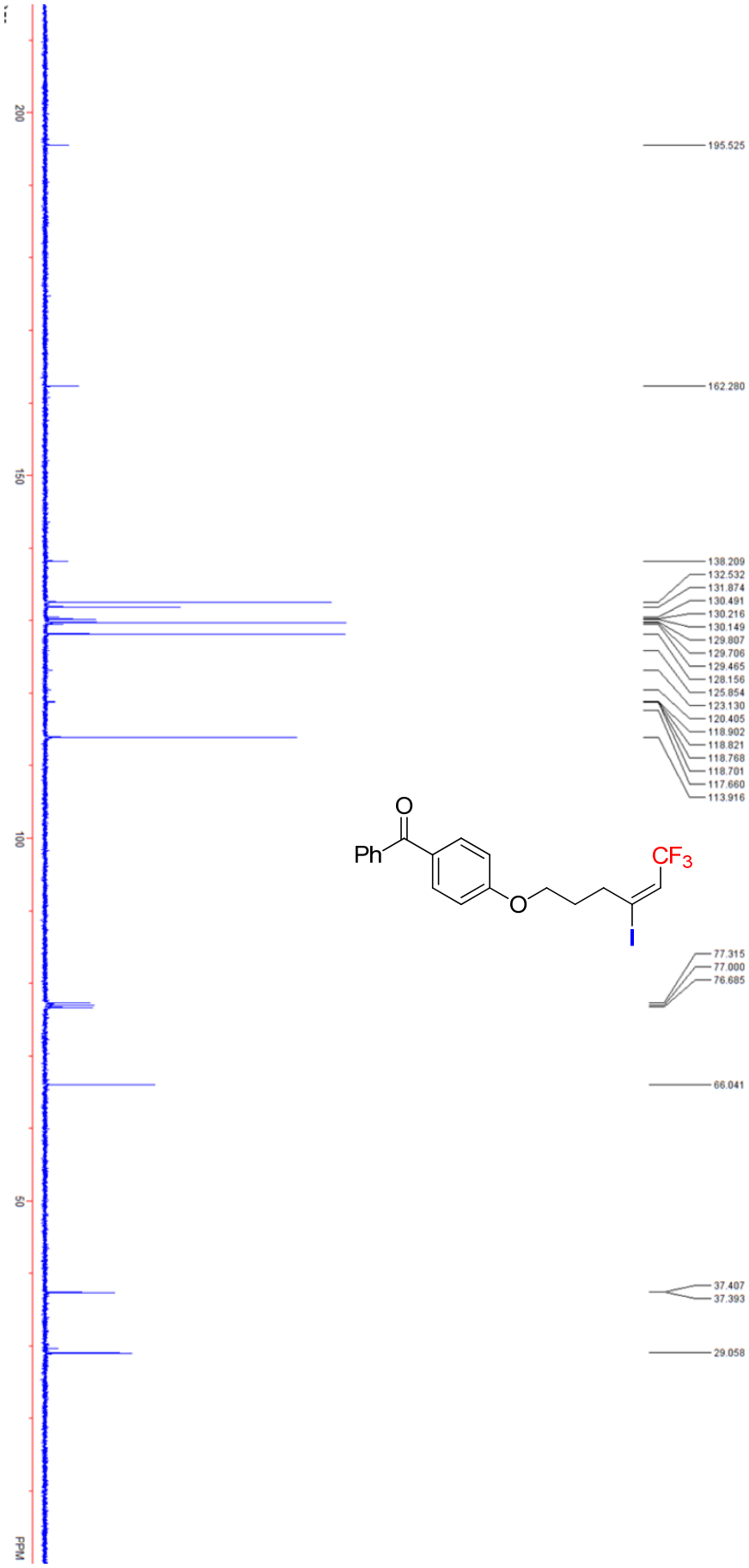
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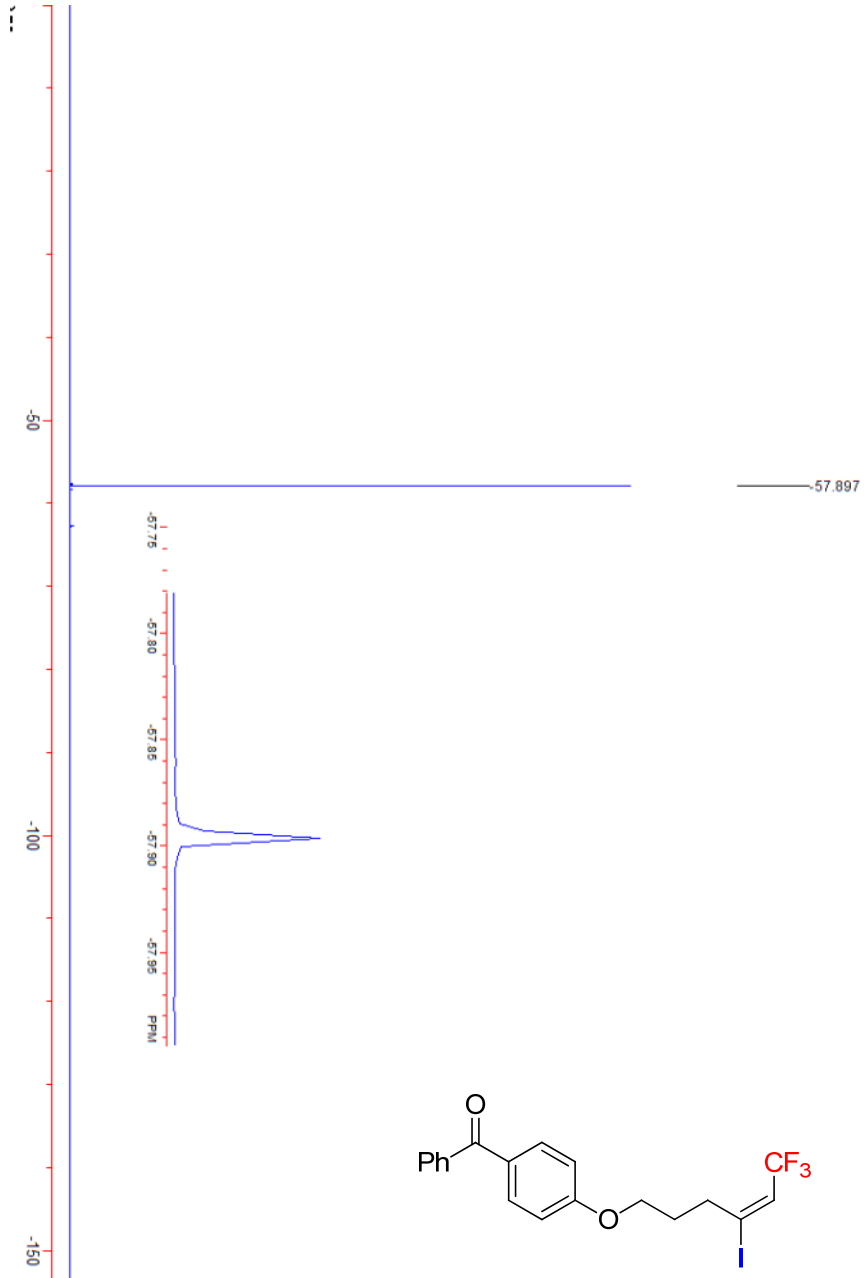
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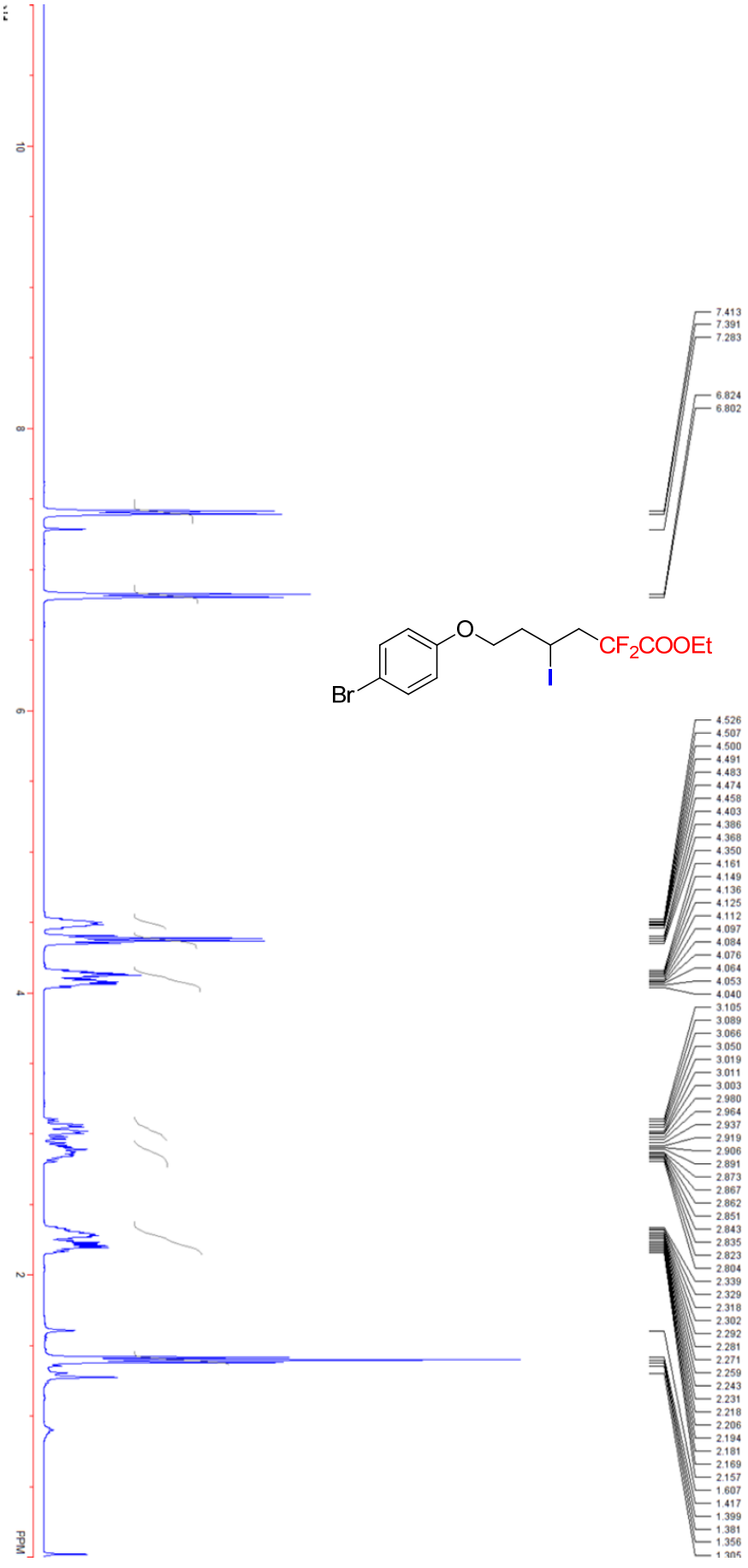
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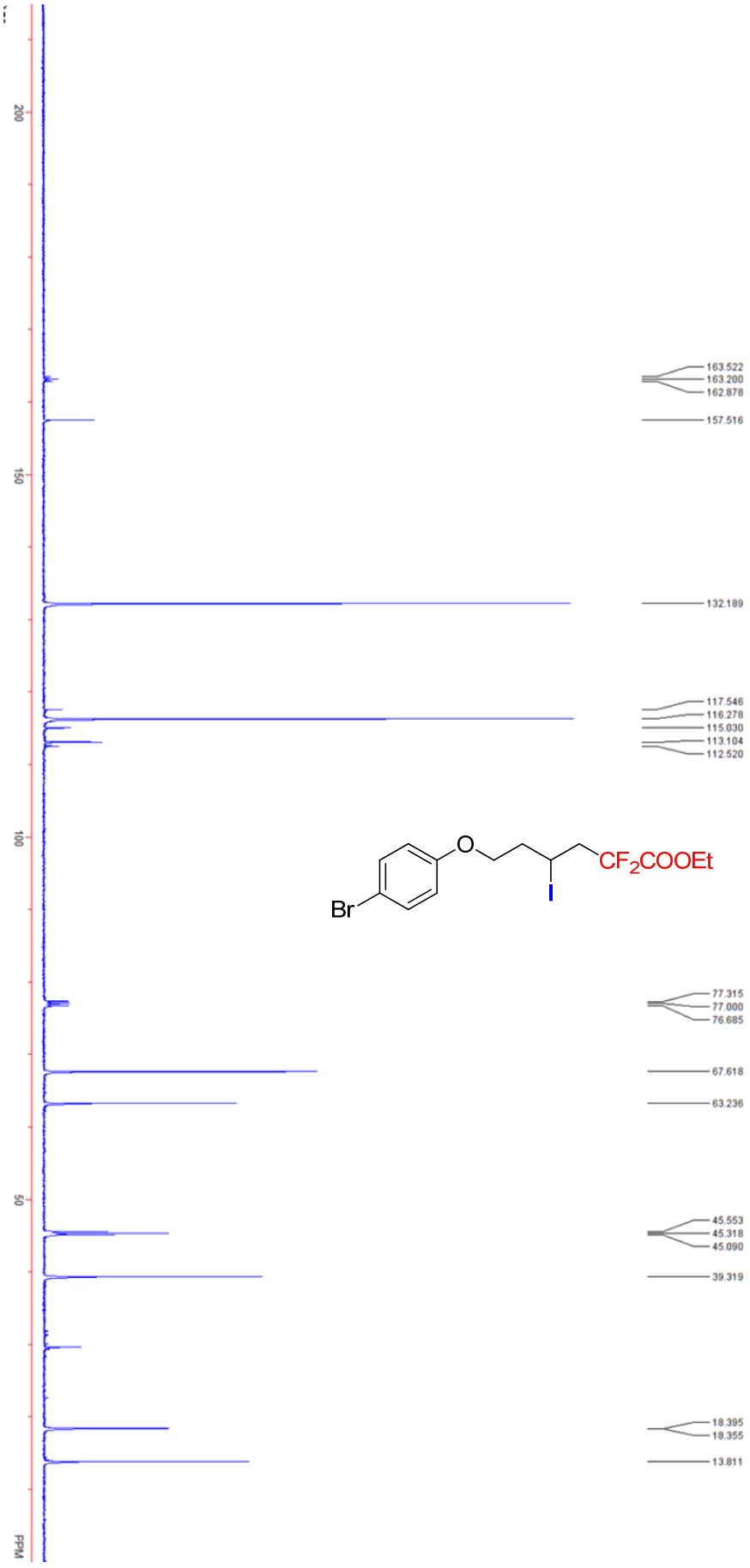
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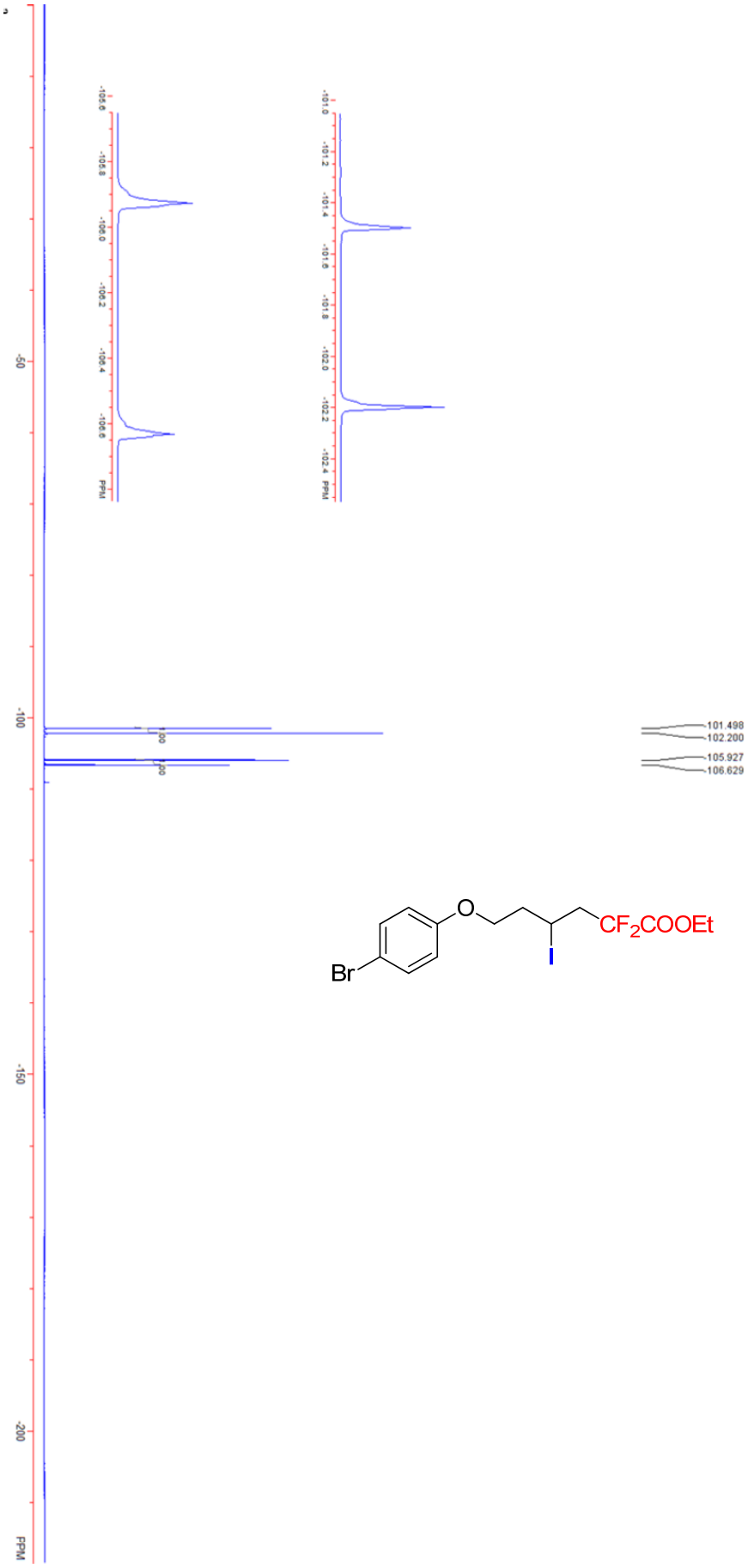
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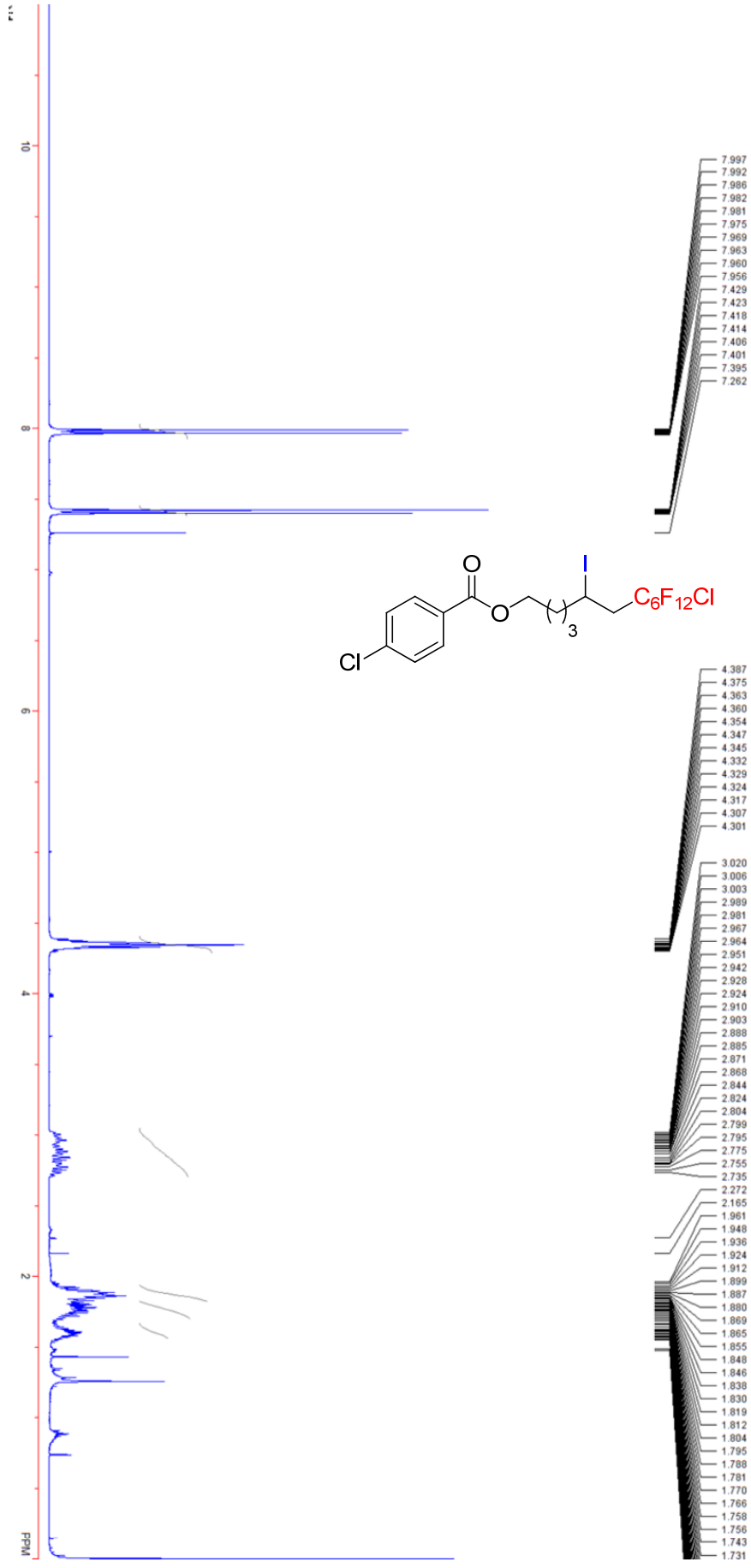
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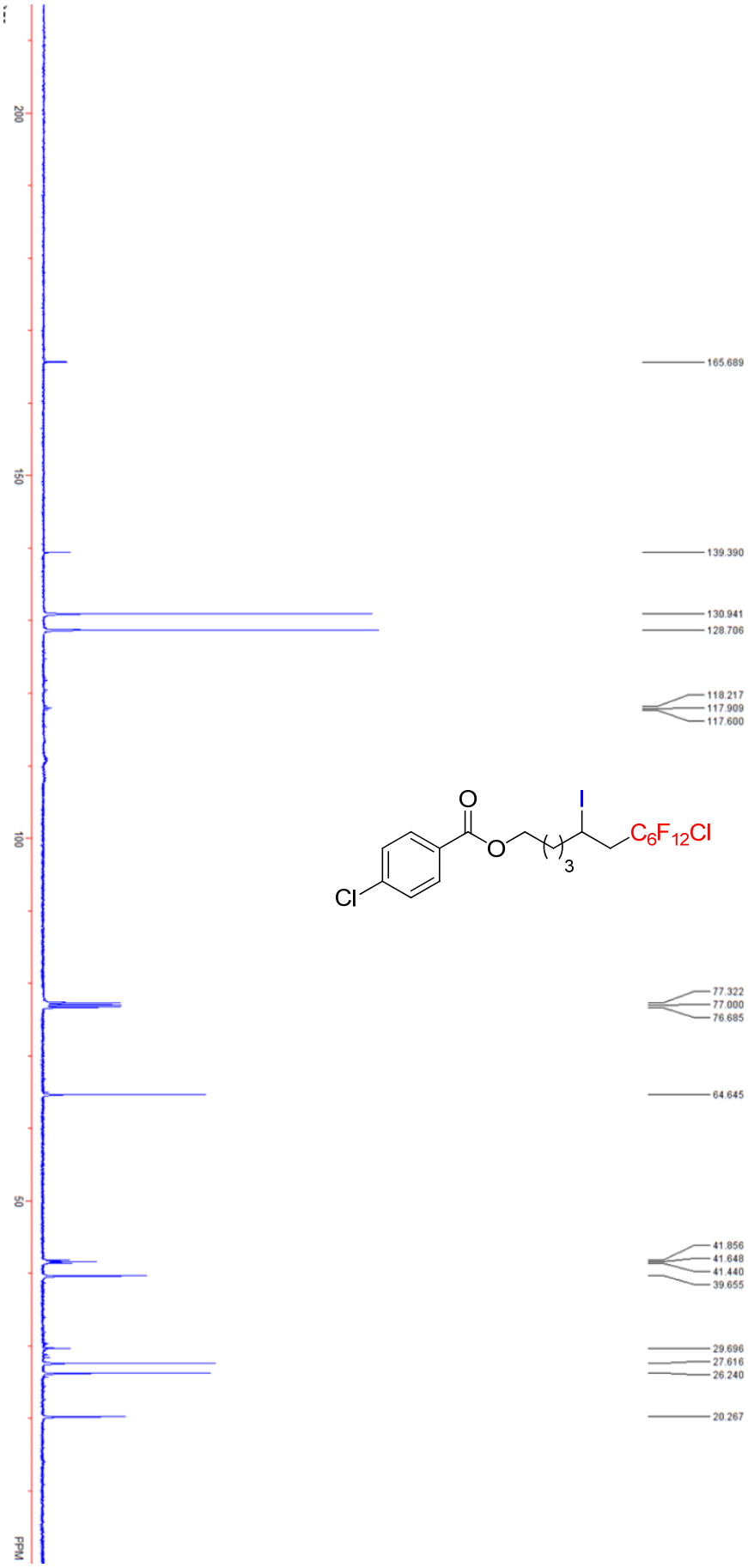
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41.648
41.440
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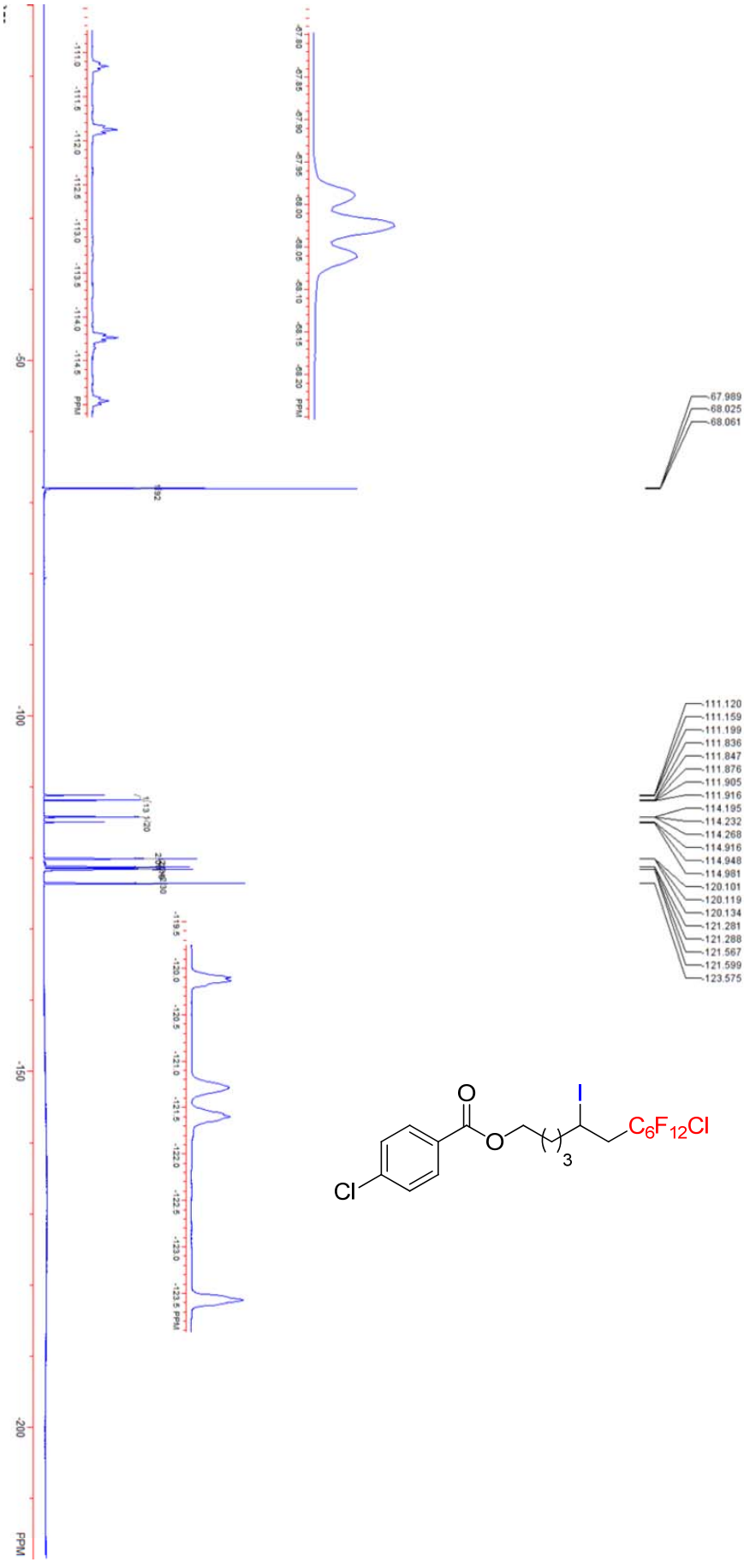
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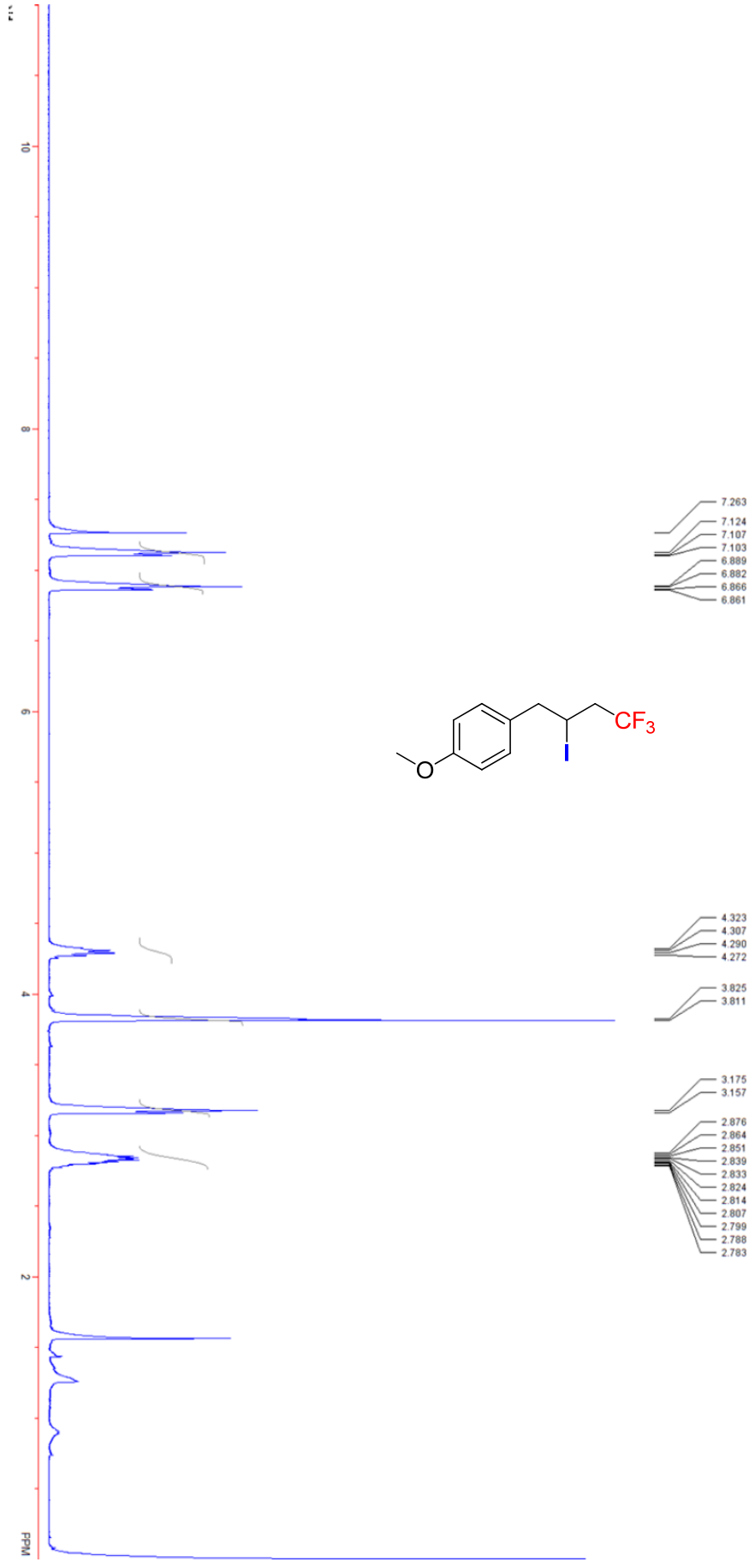
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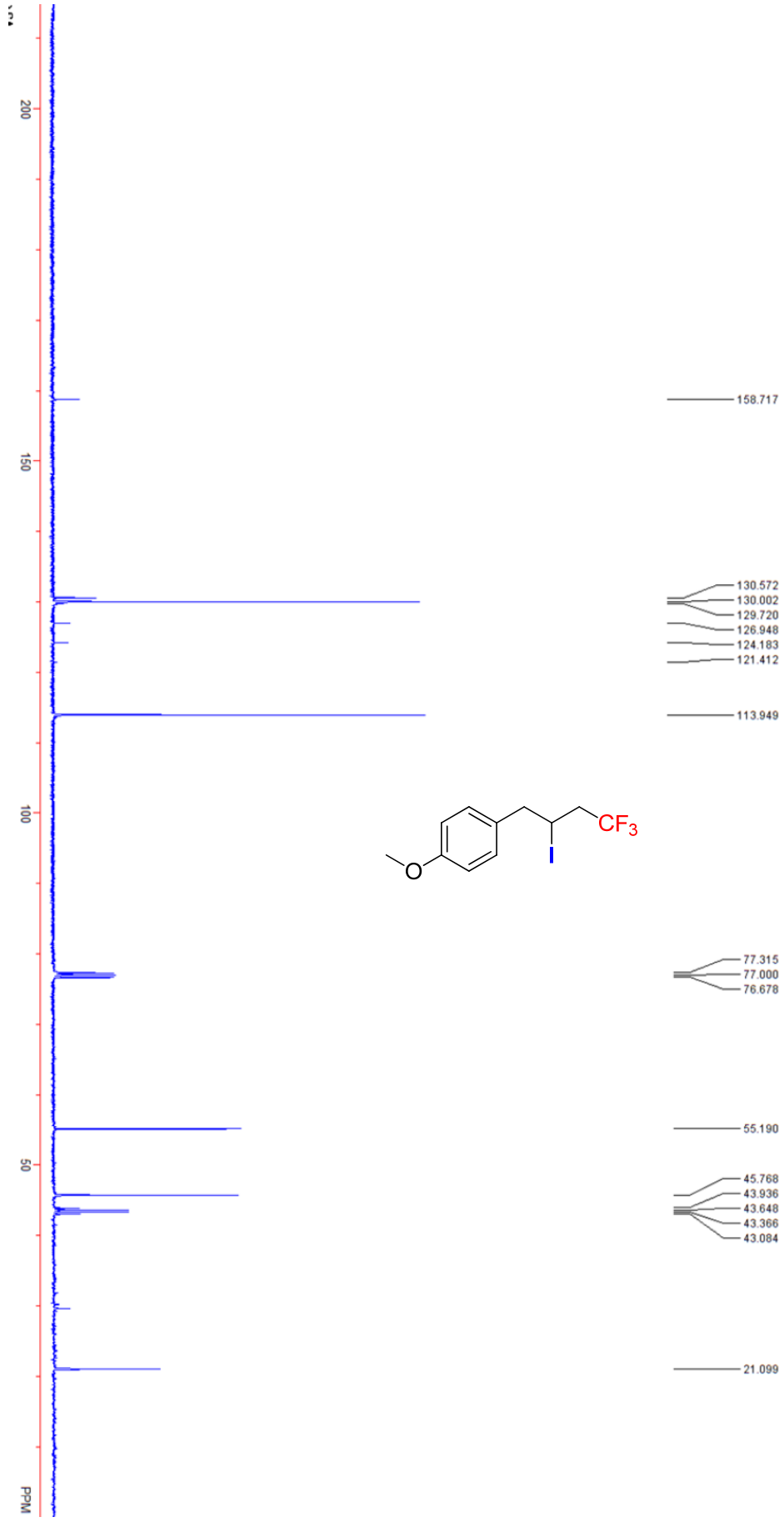
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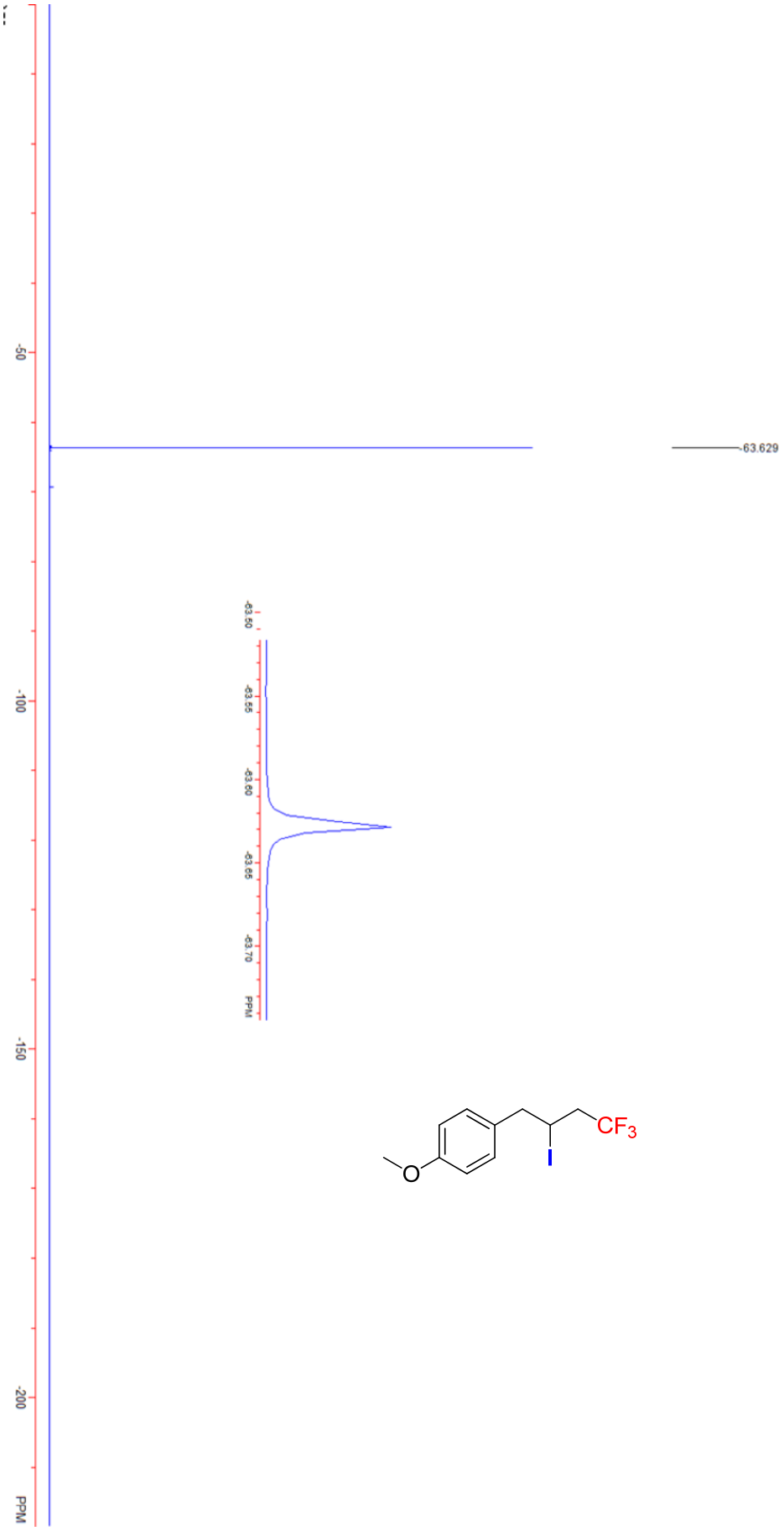
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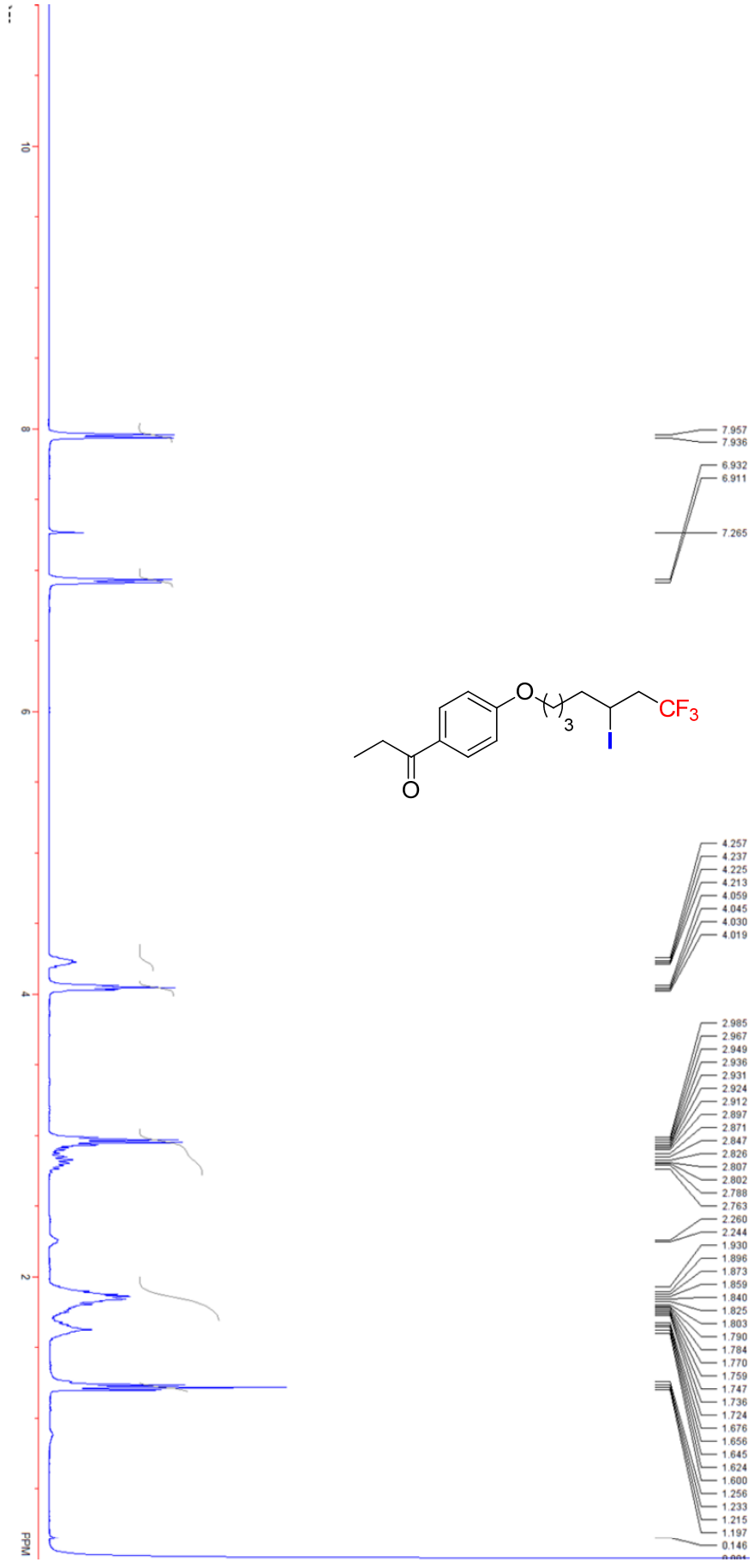
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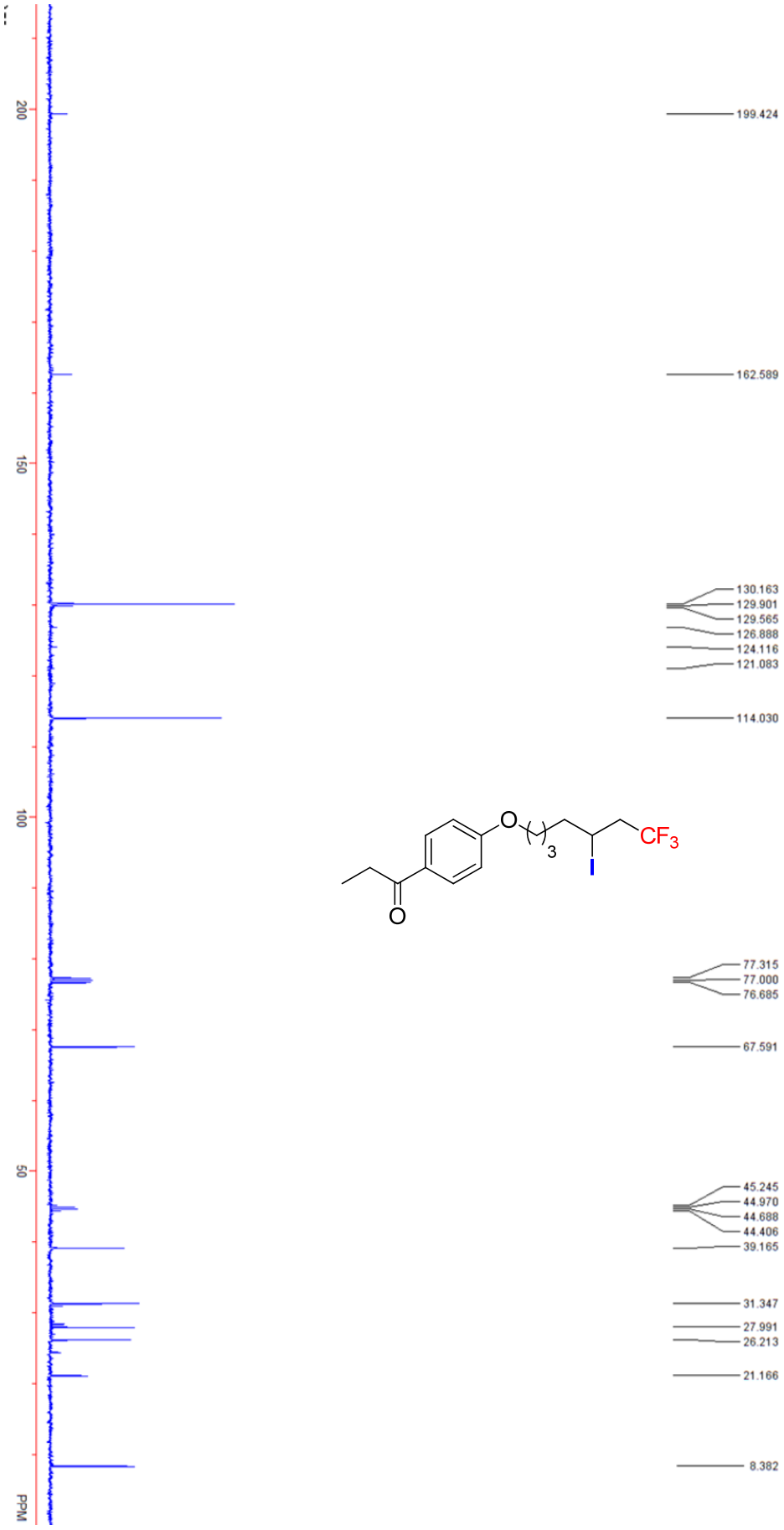
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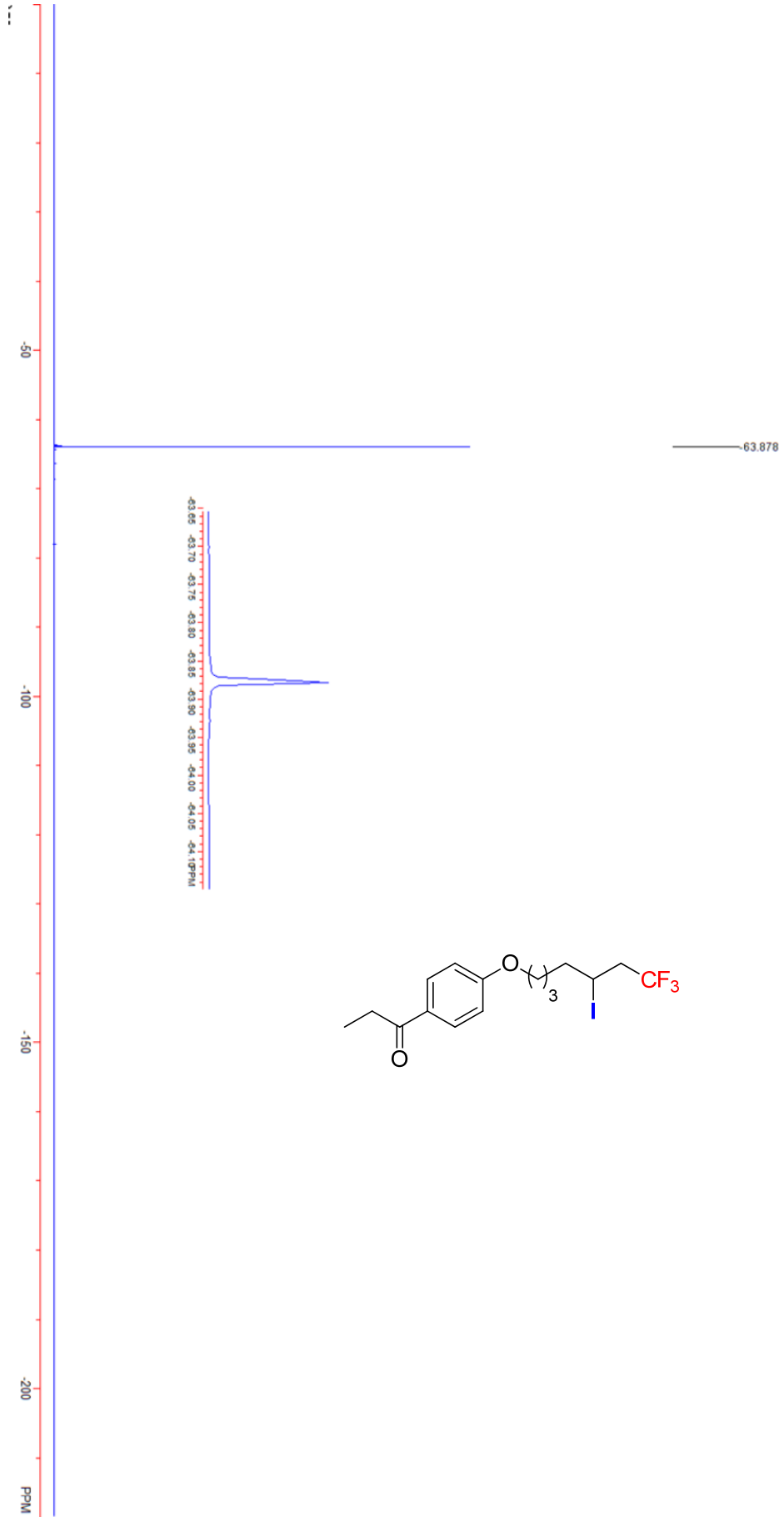
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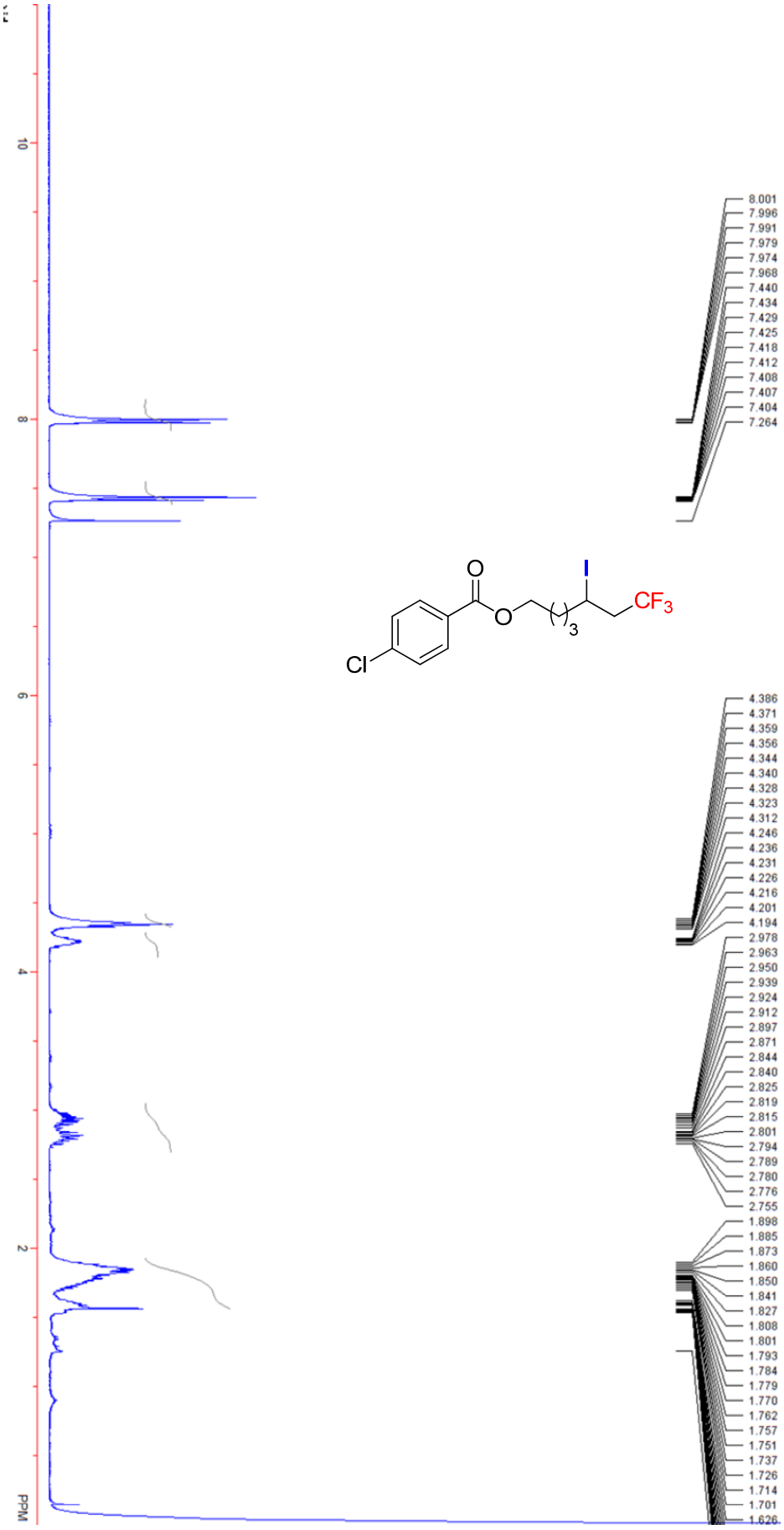
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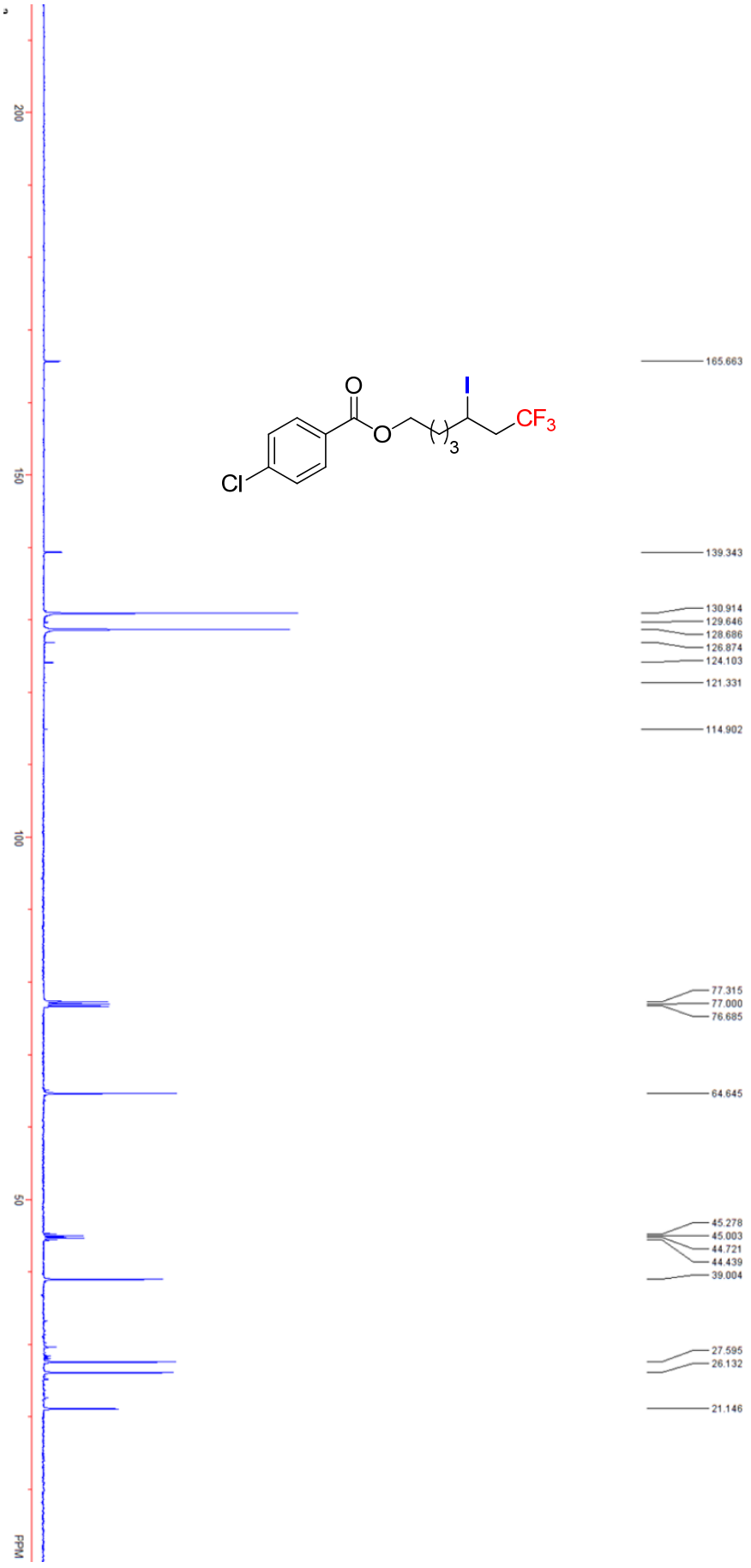
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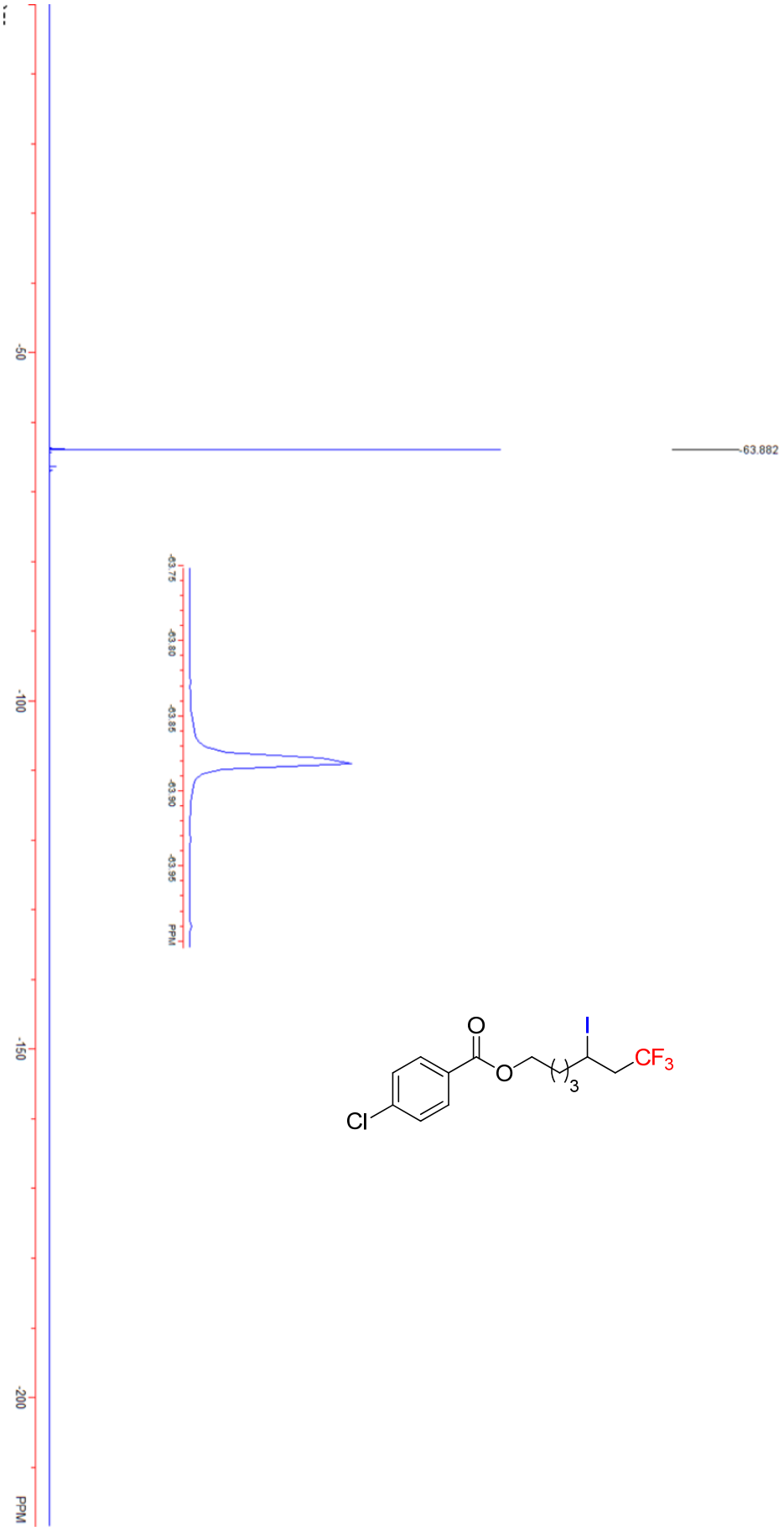
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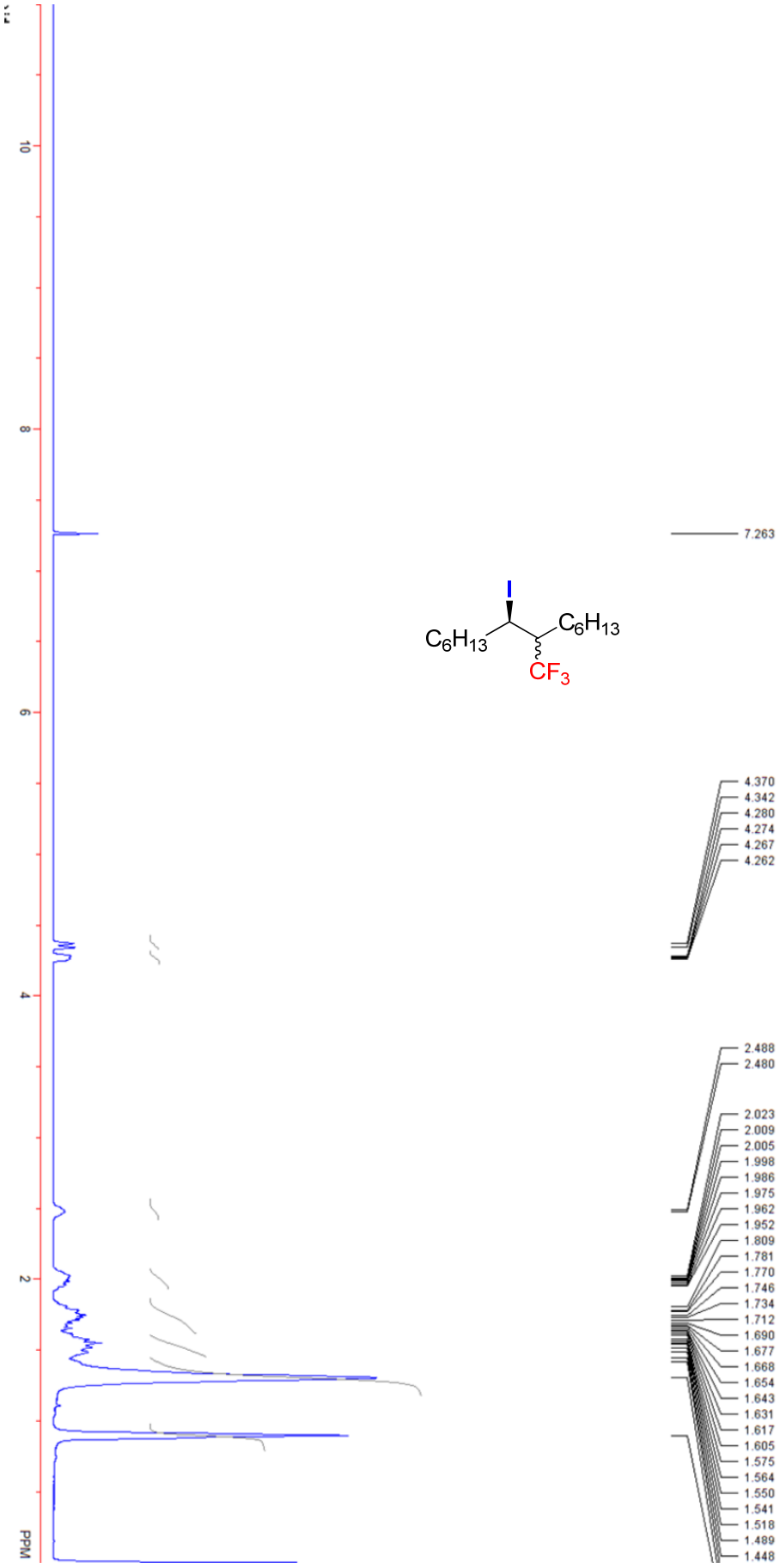
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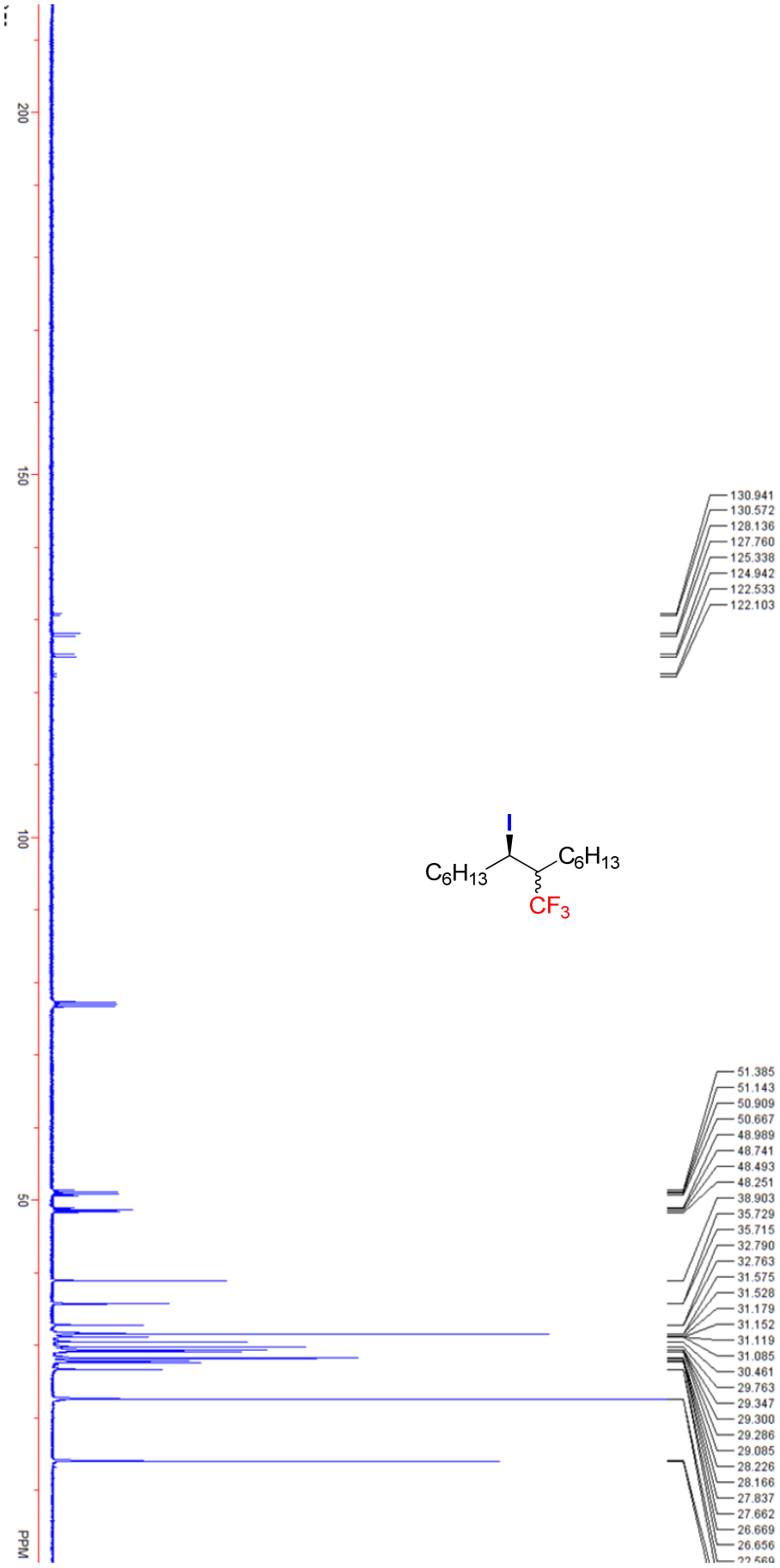
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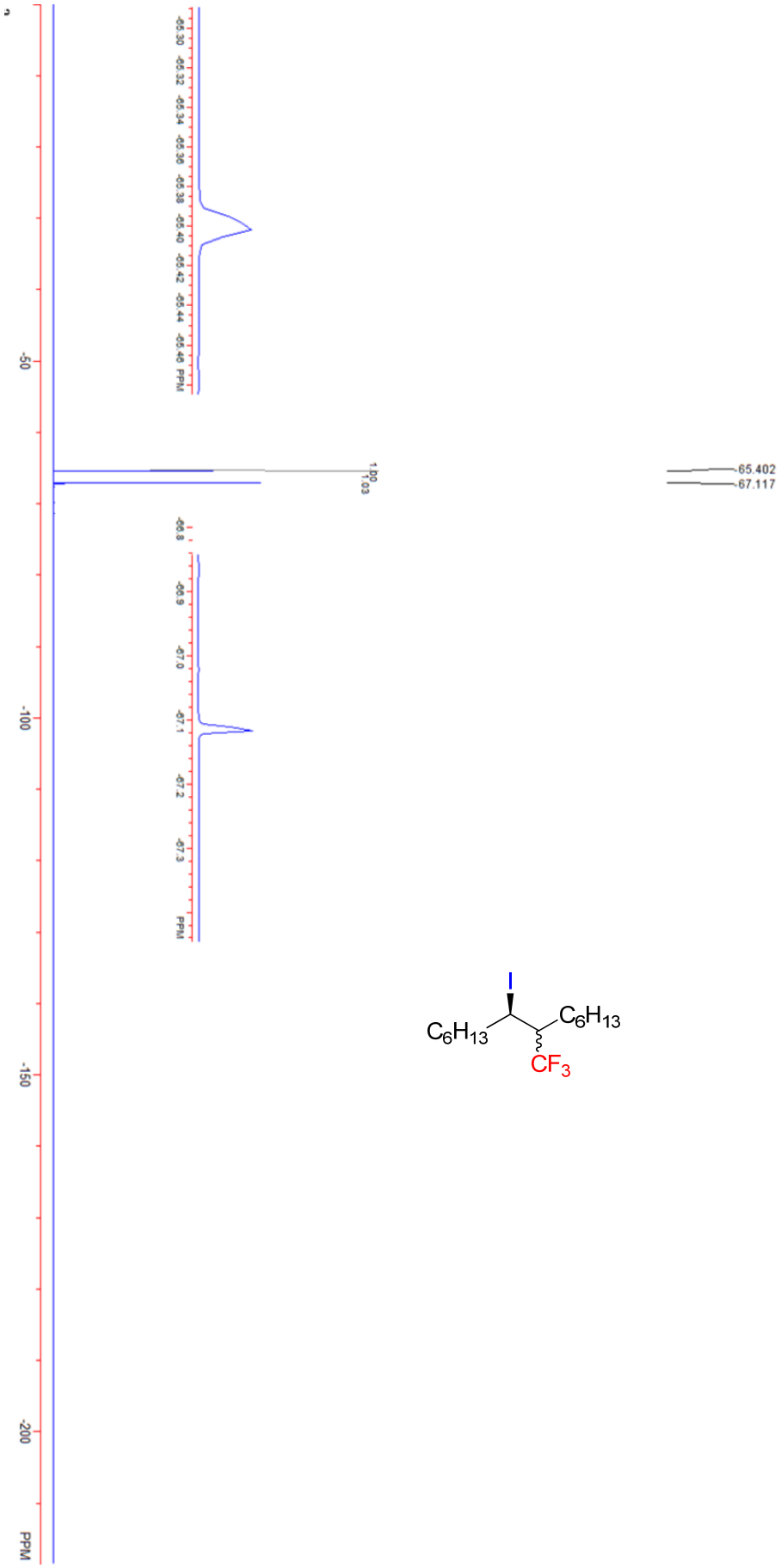
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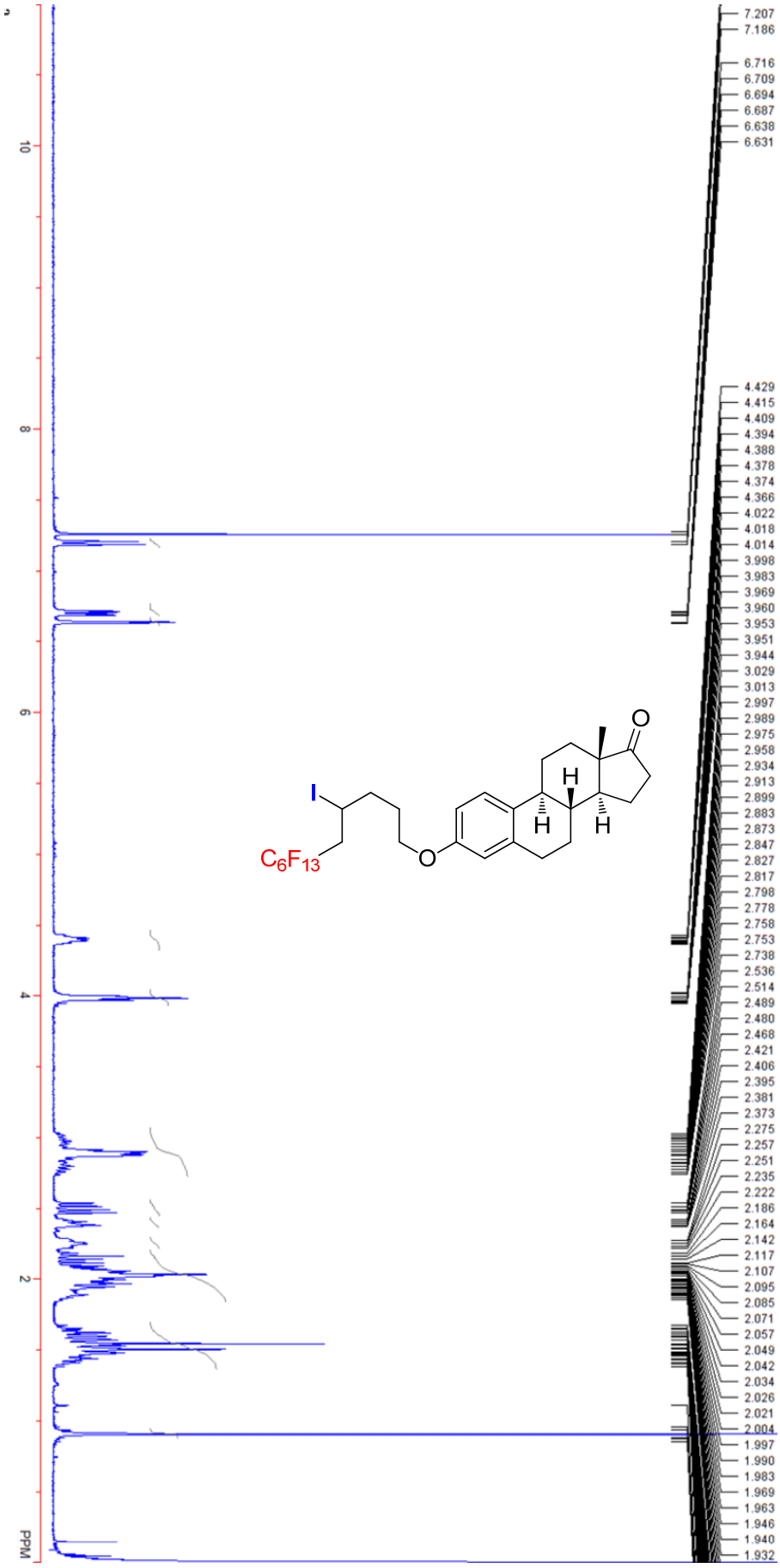
C6H13
CF3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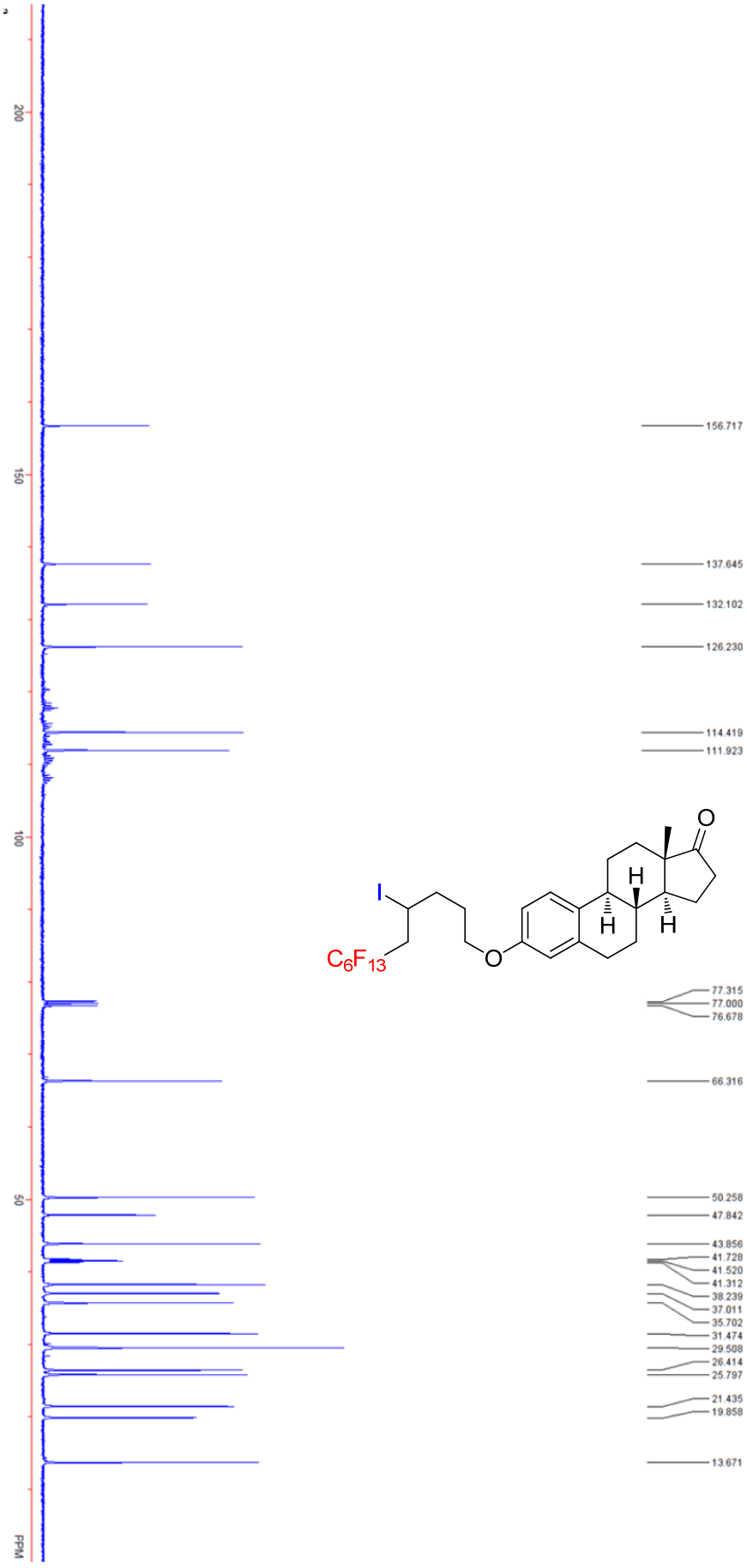
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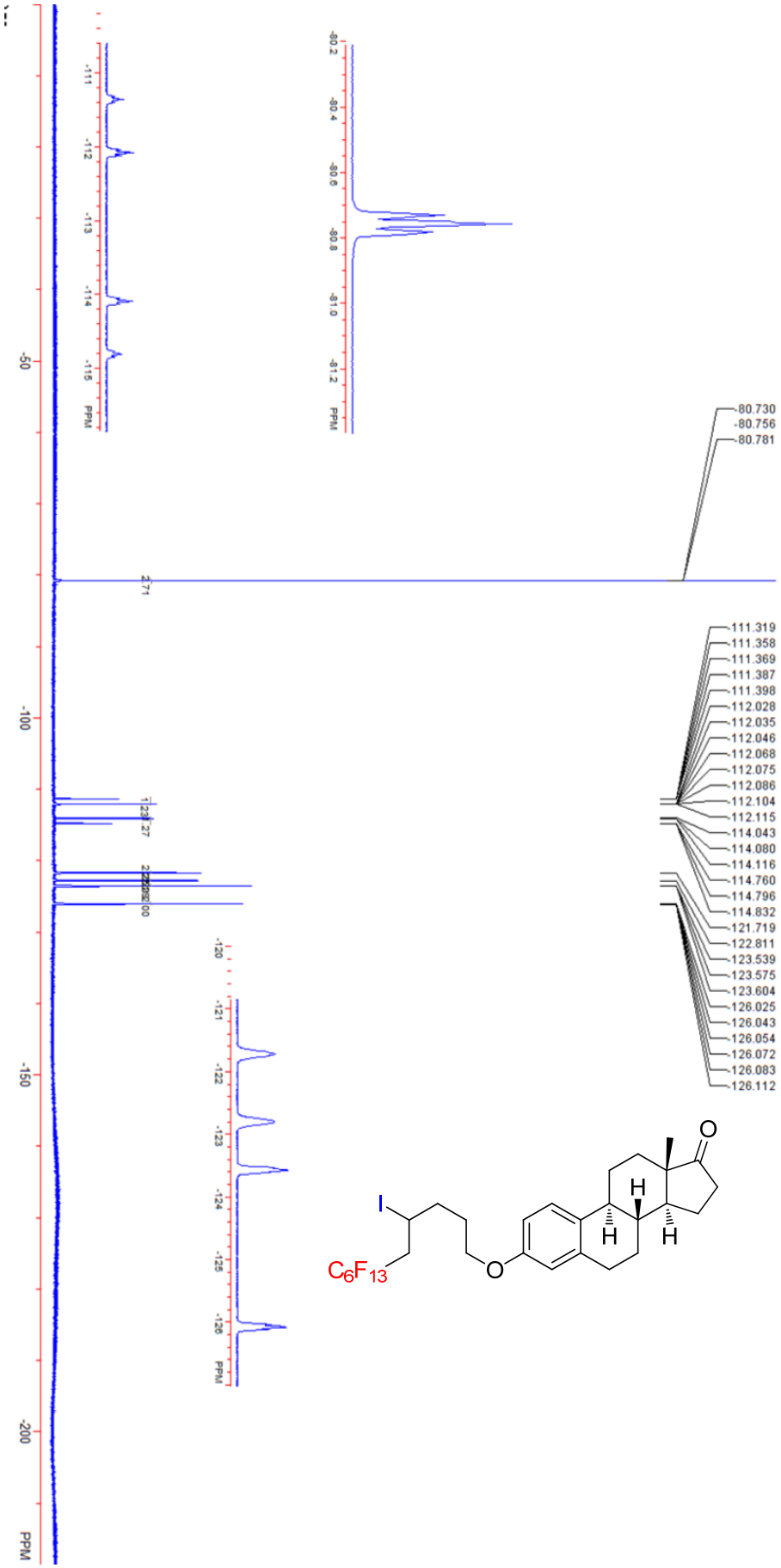
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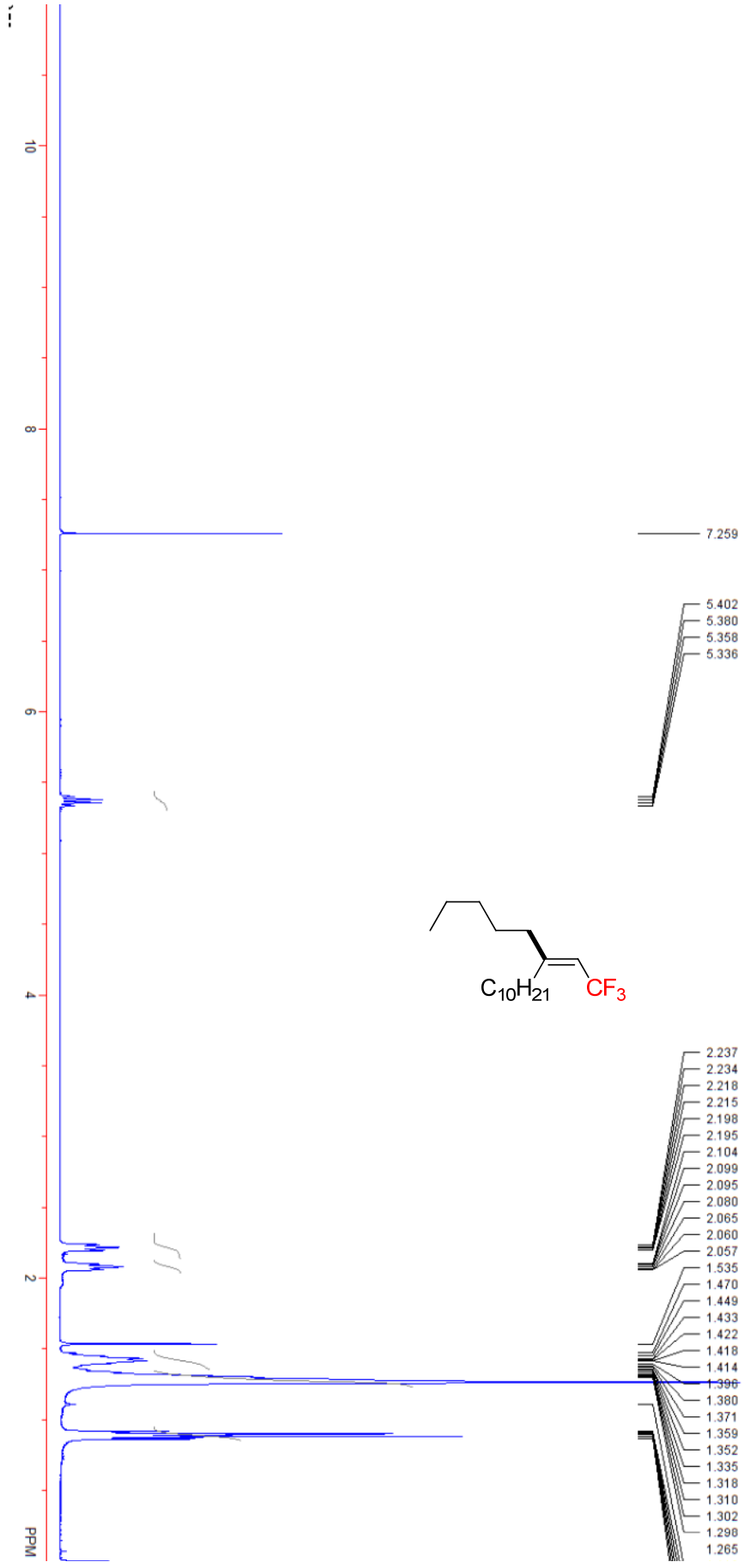
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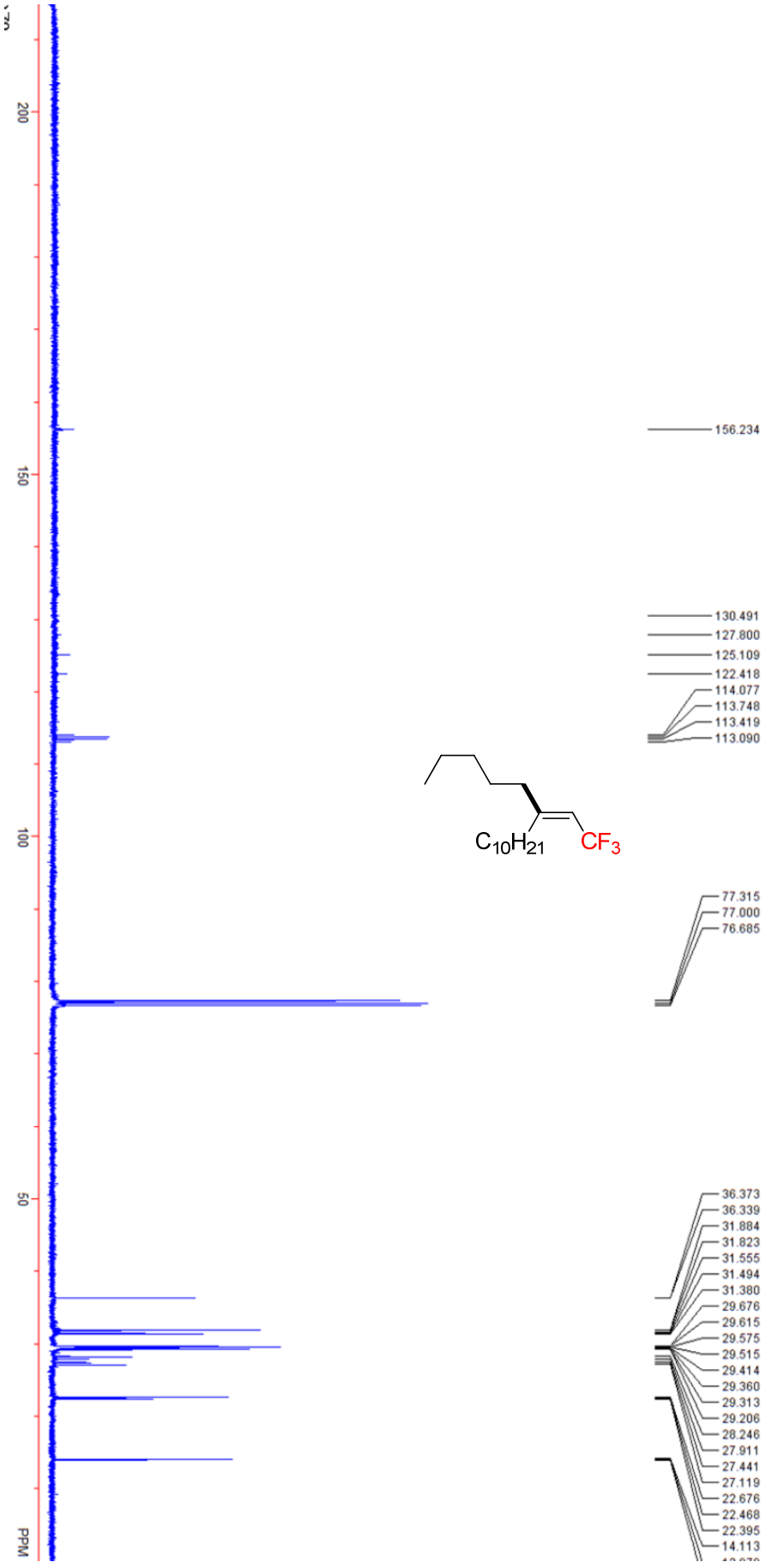
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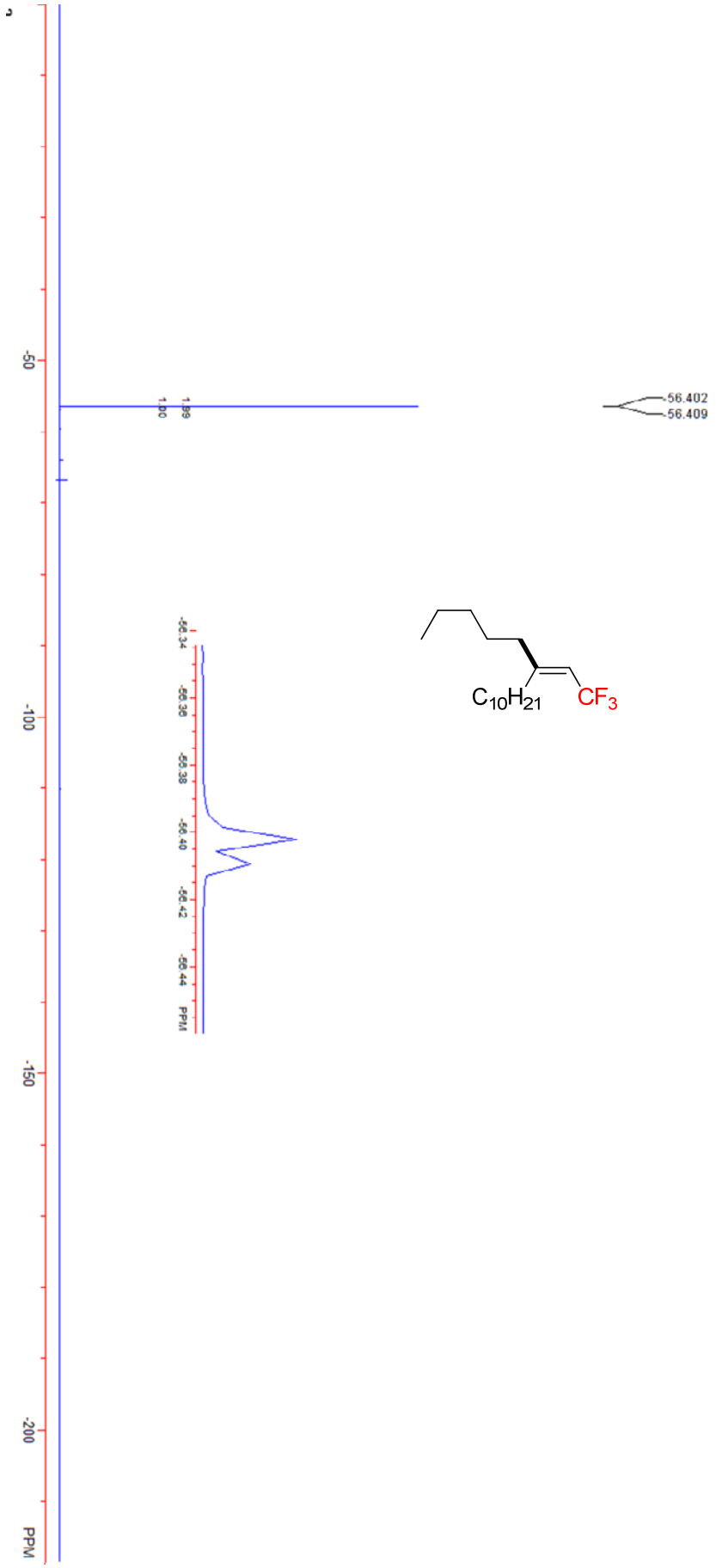
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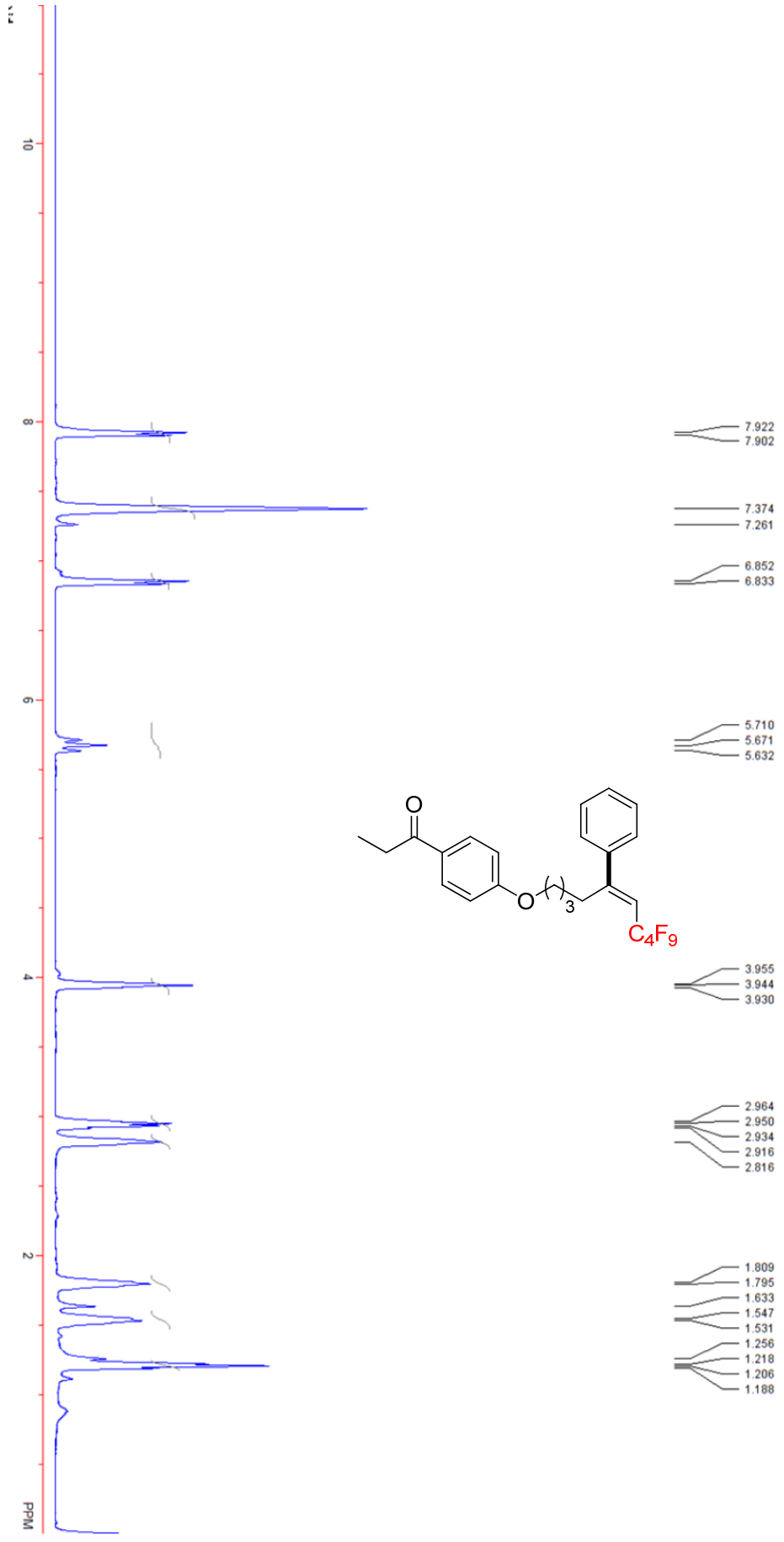
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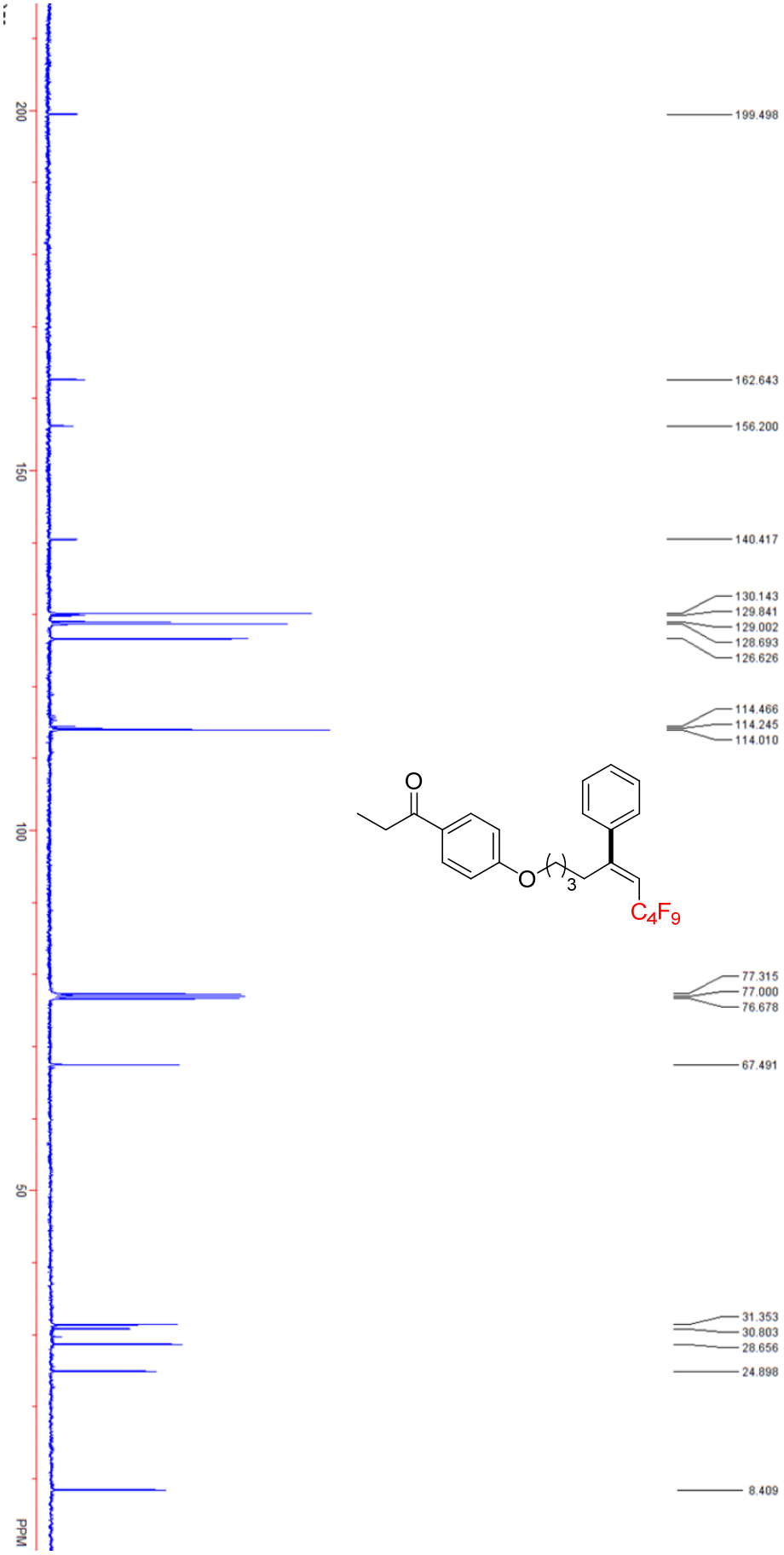
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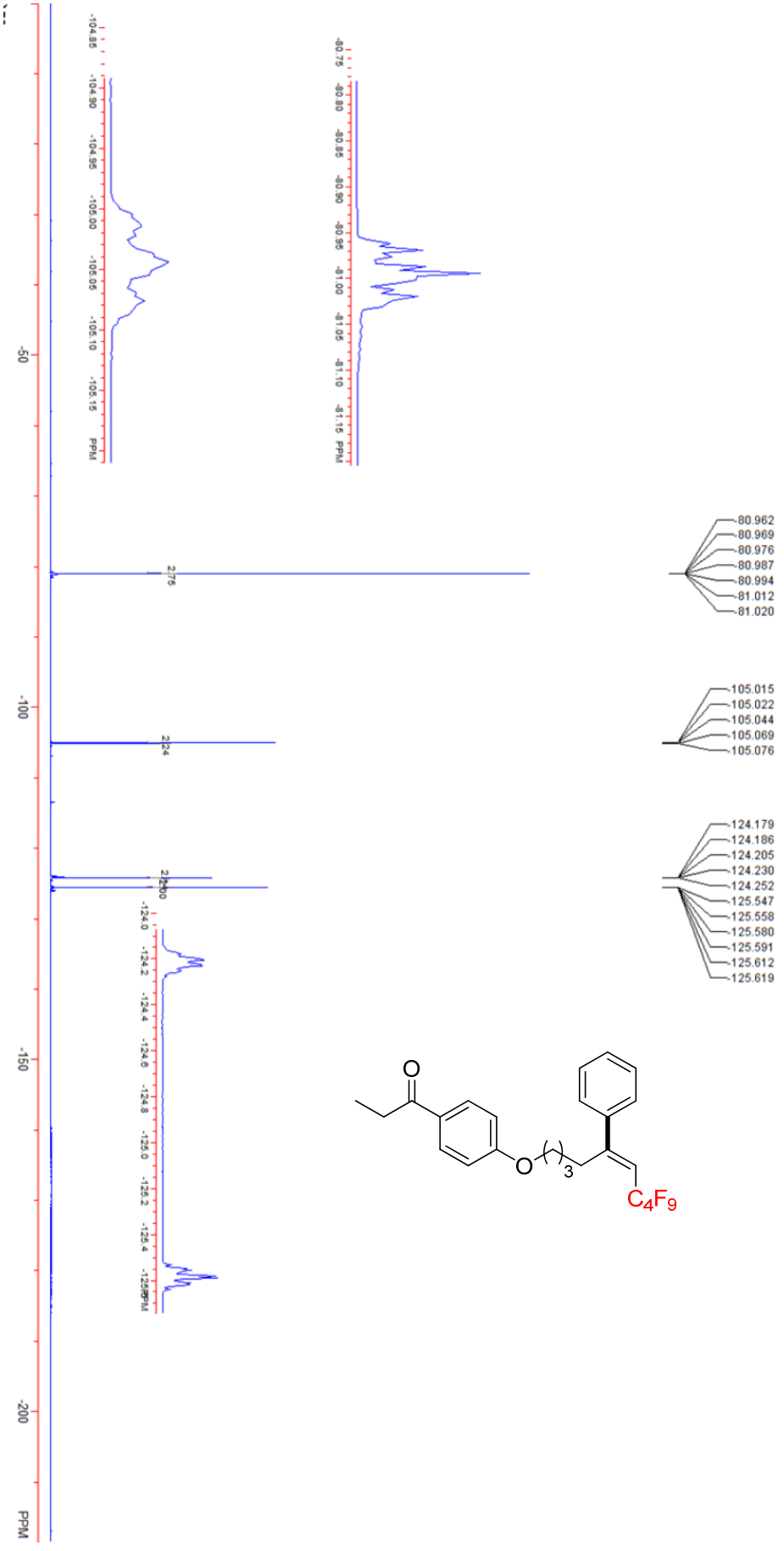
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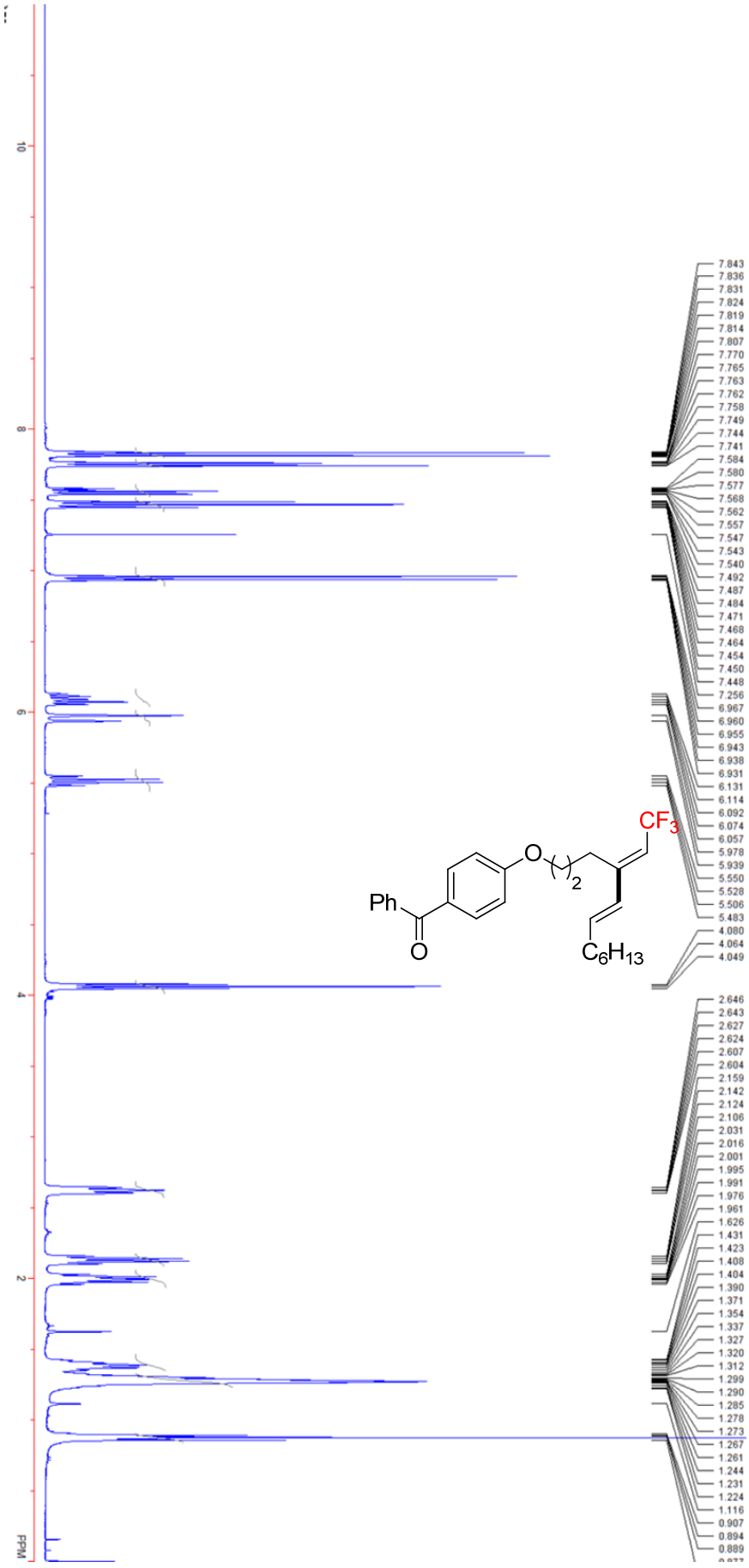
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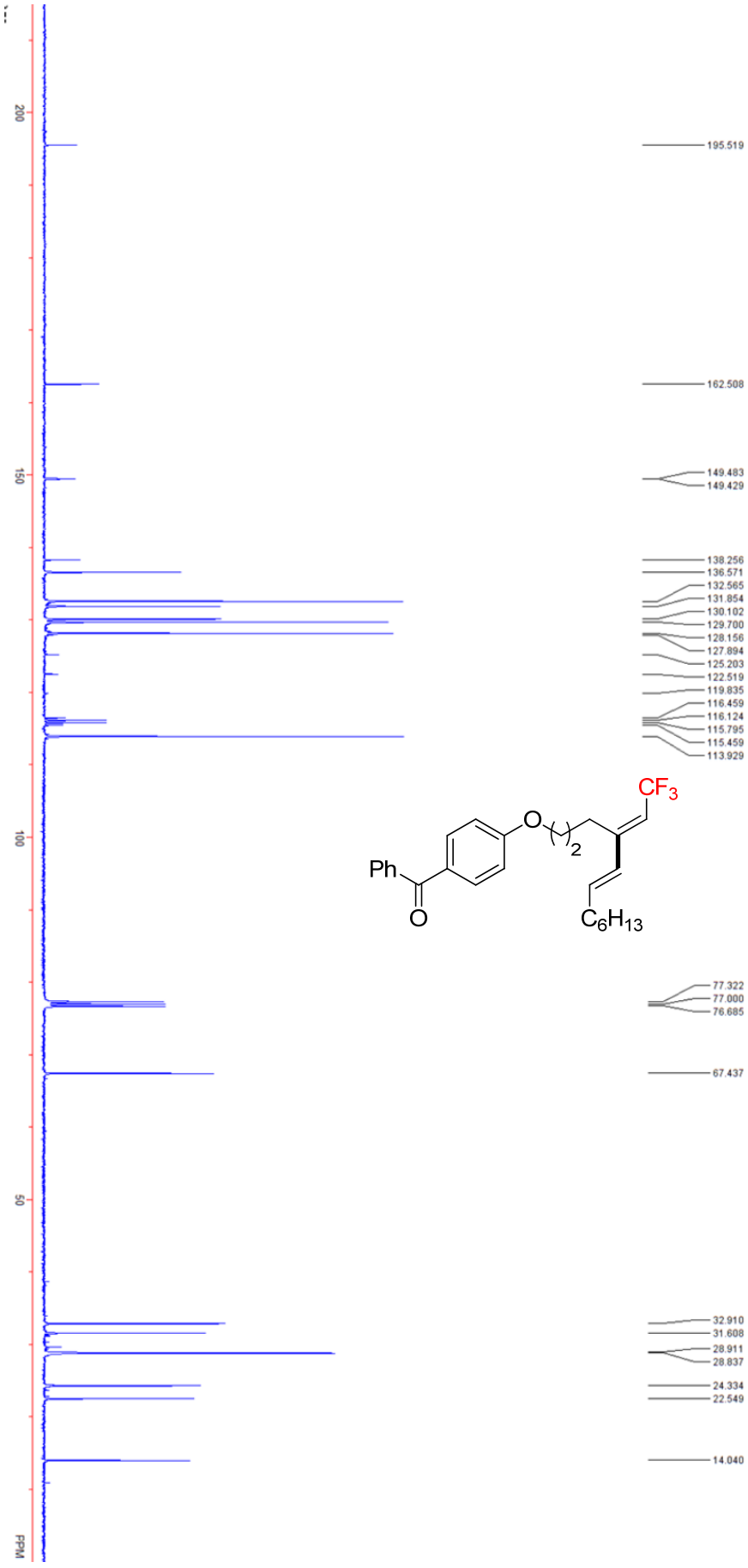
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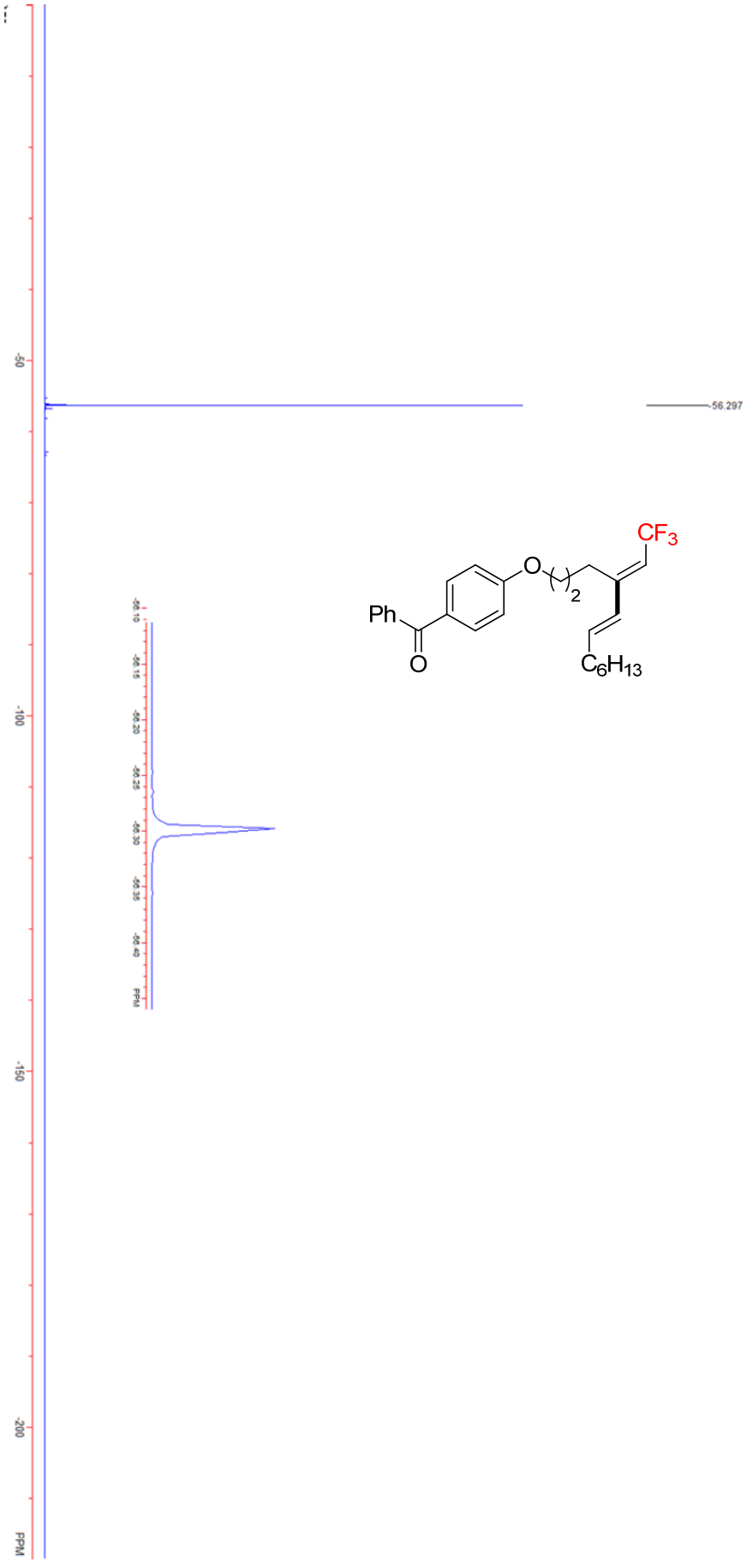
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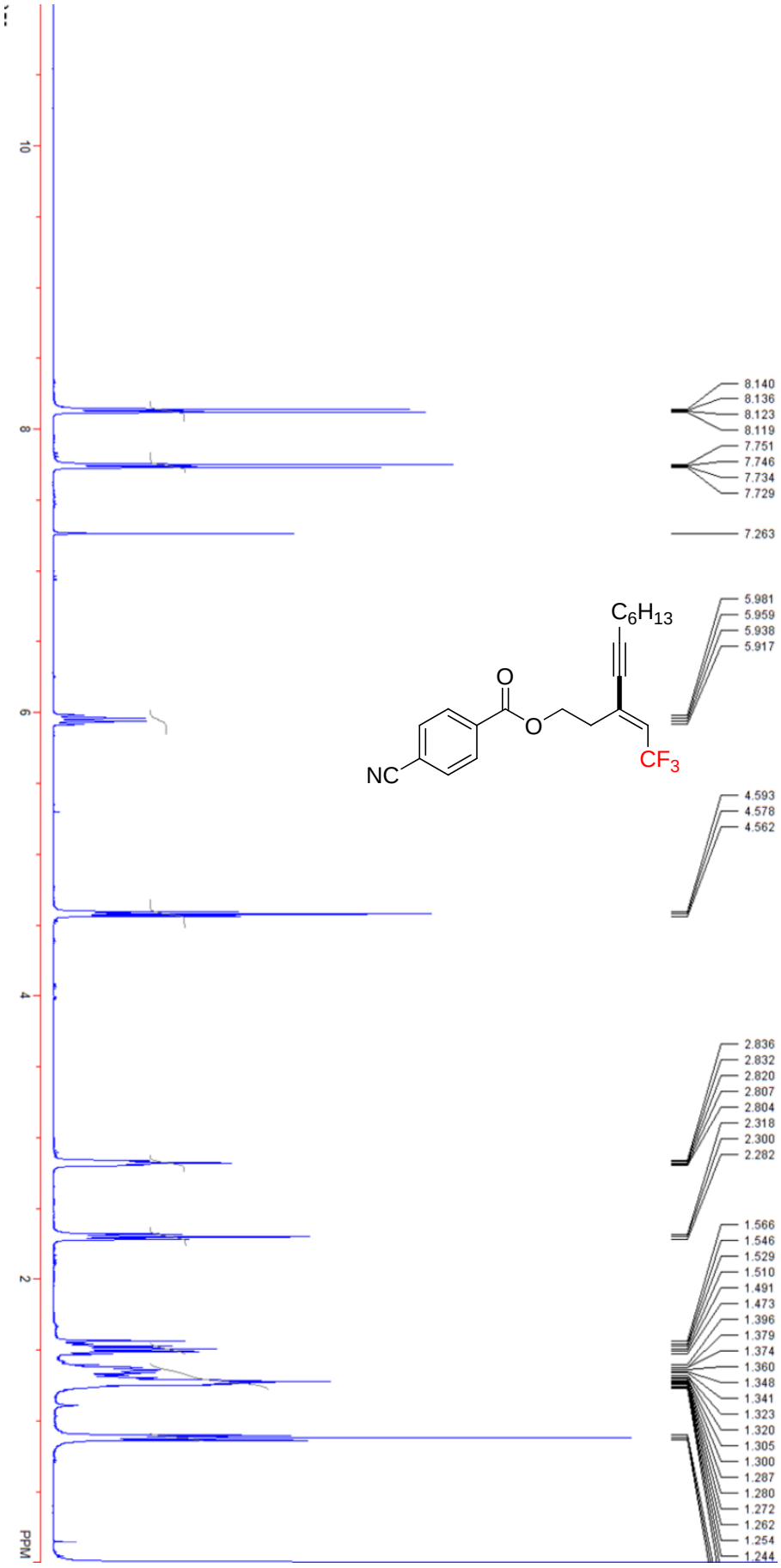
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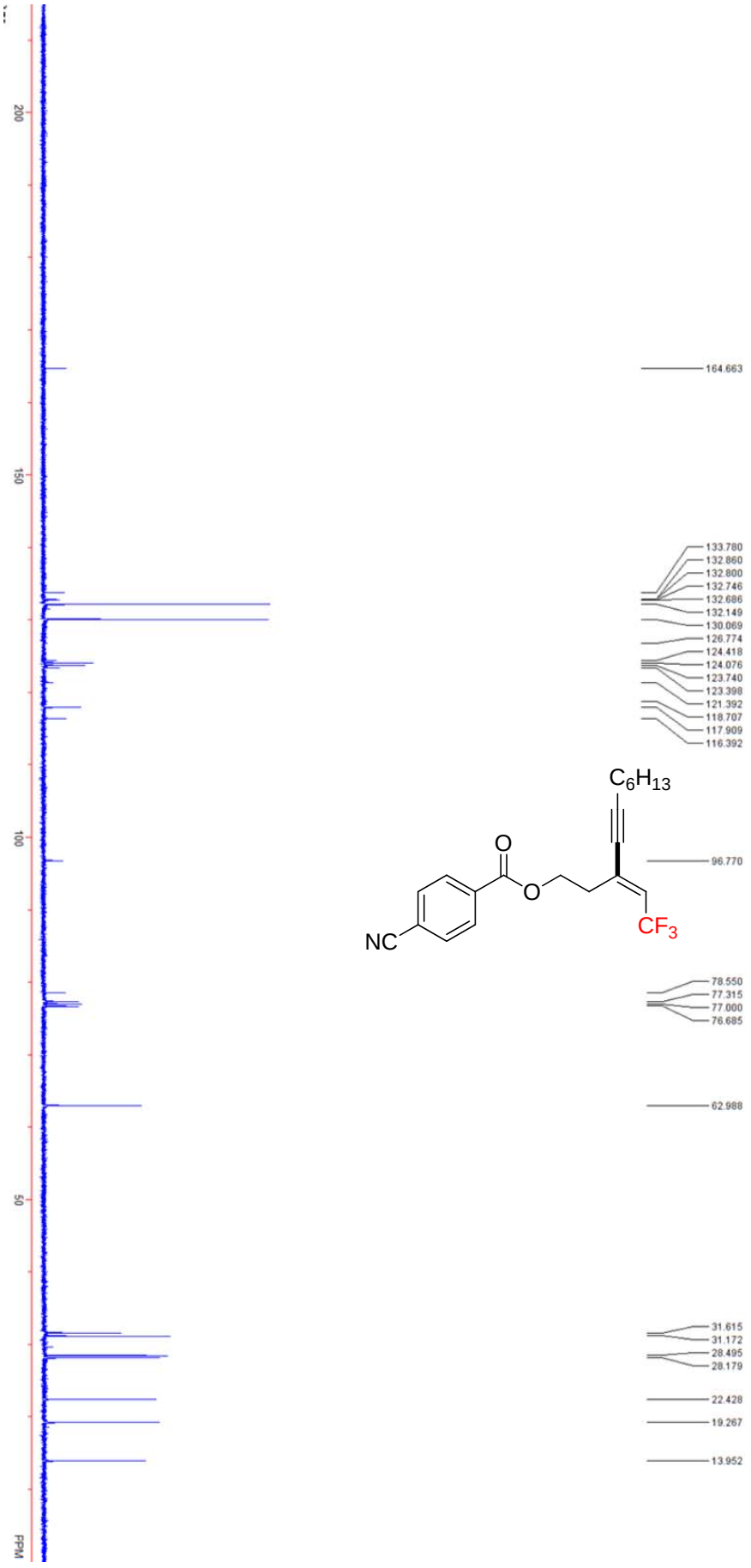
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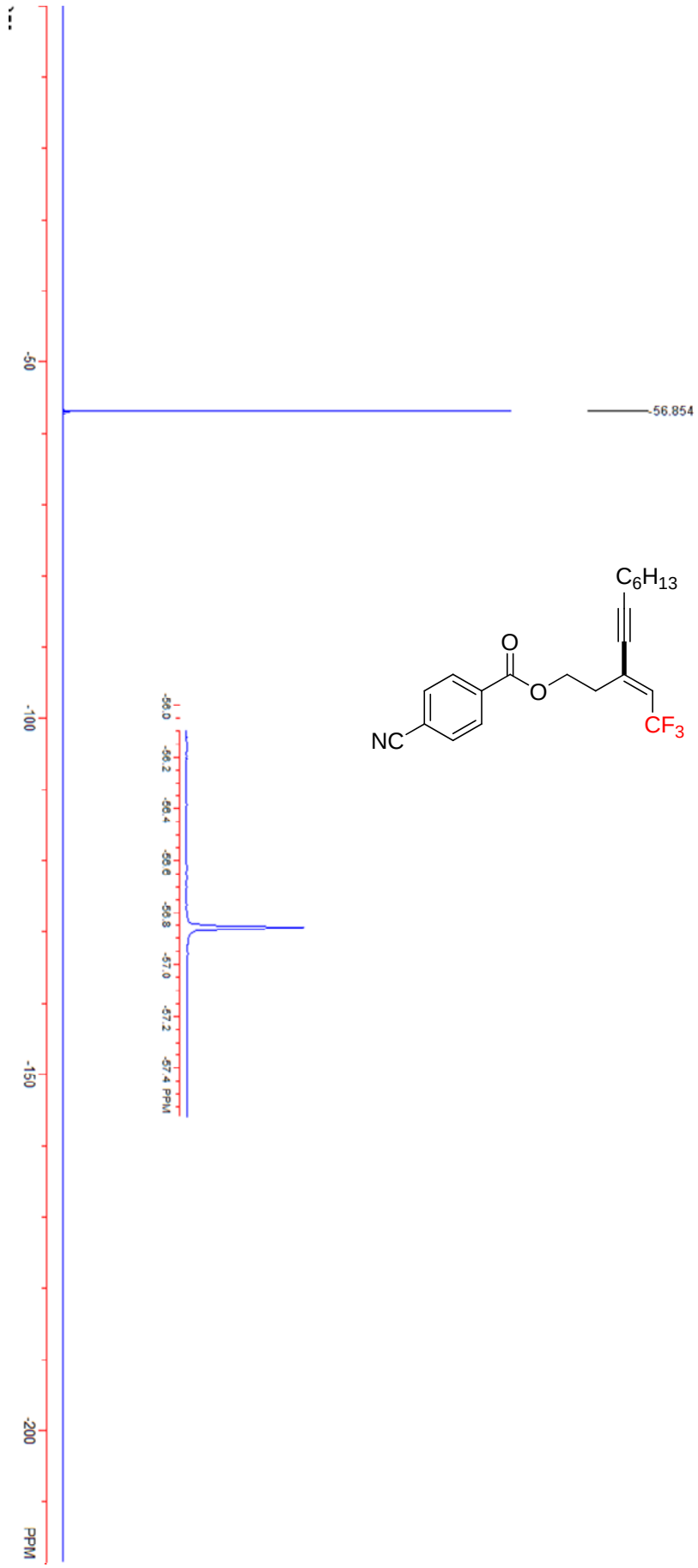
CF3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-57.4 PPM
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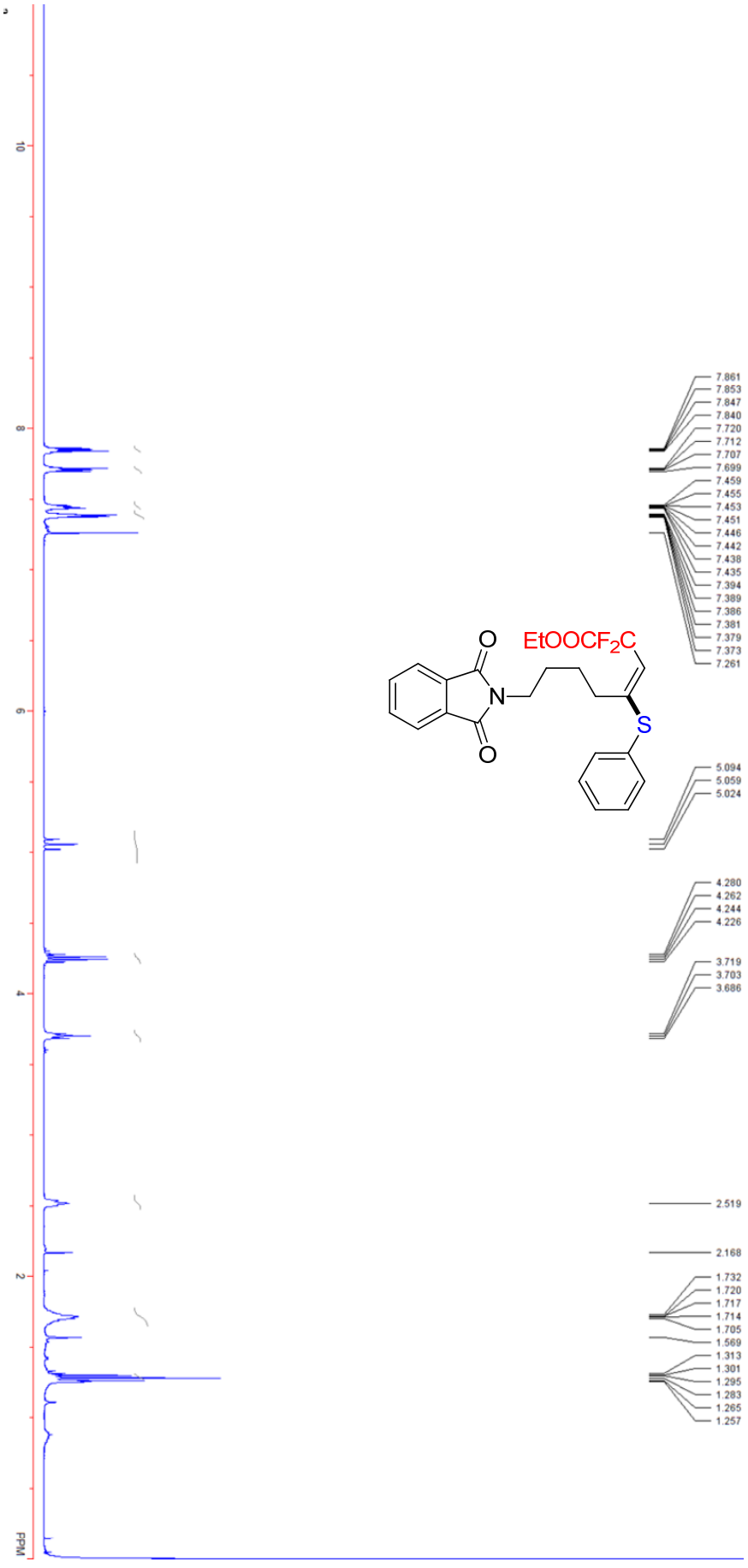
NC
CF3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7.435
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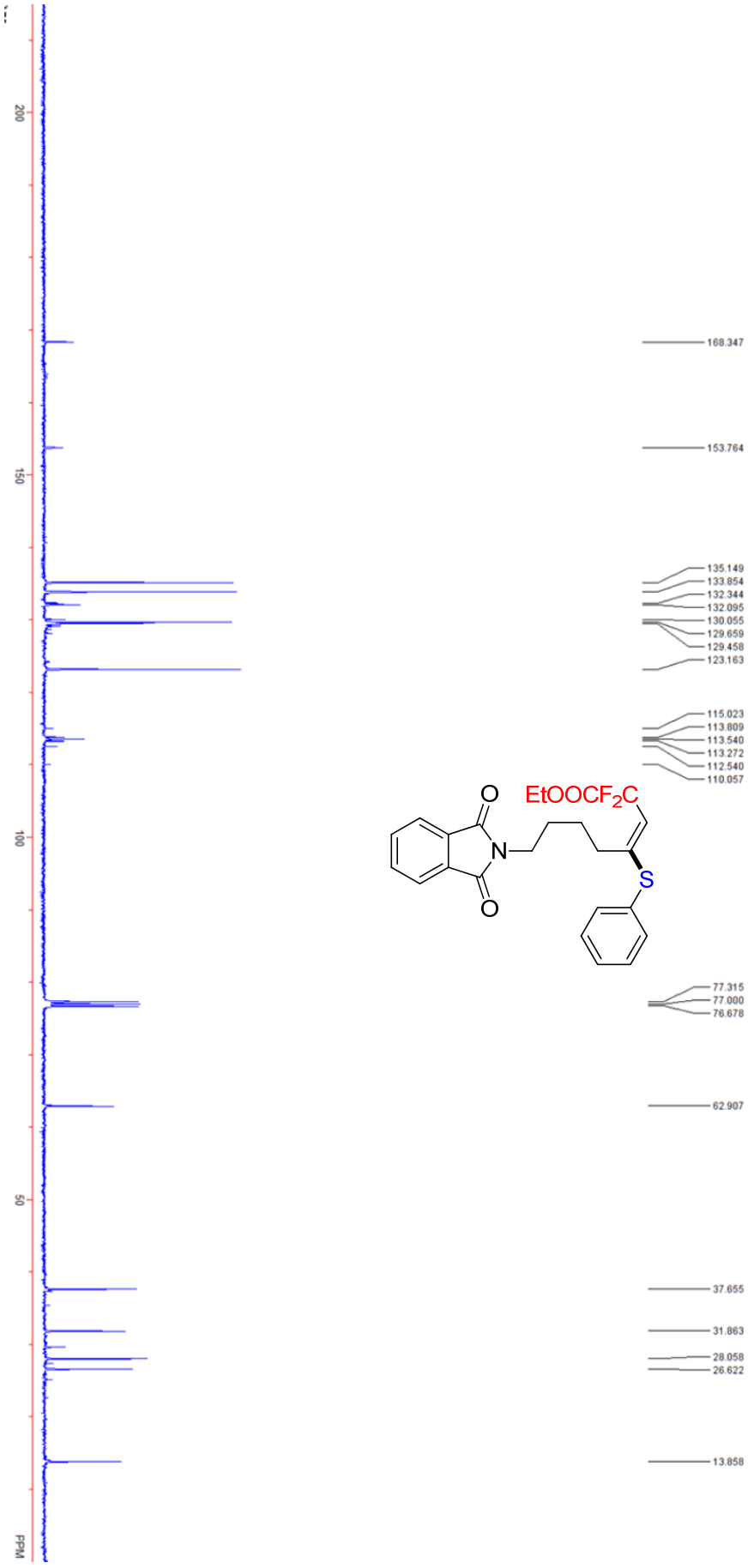
PPM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113.540
113.272
112.540
110.057
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76.678
62.907
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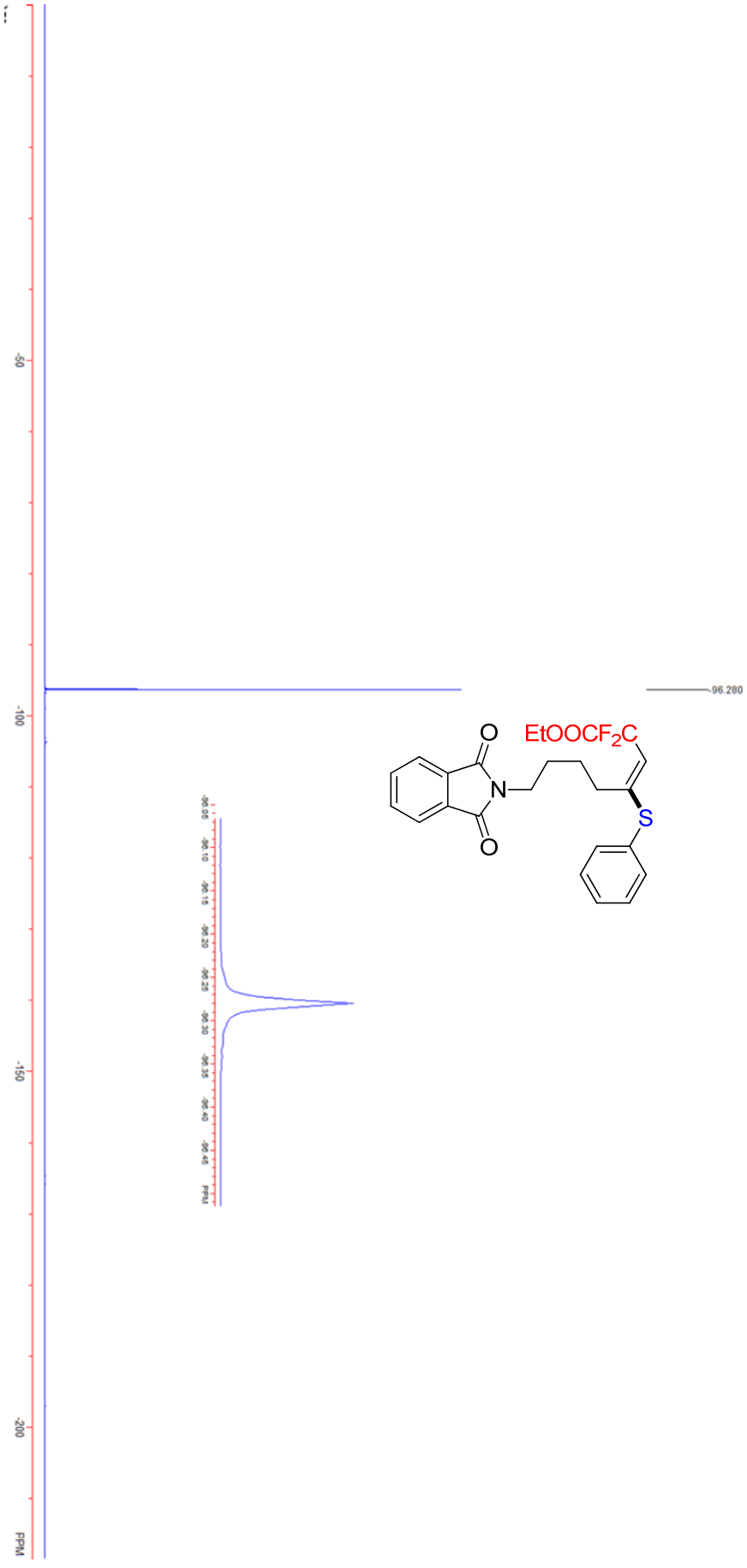
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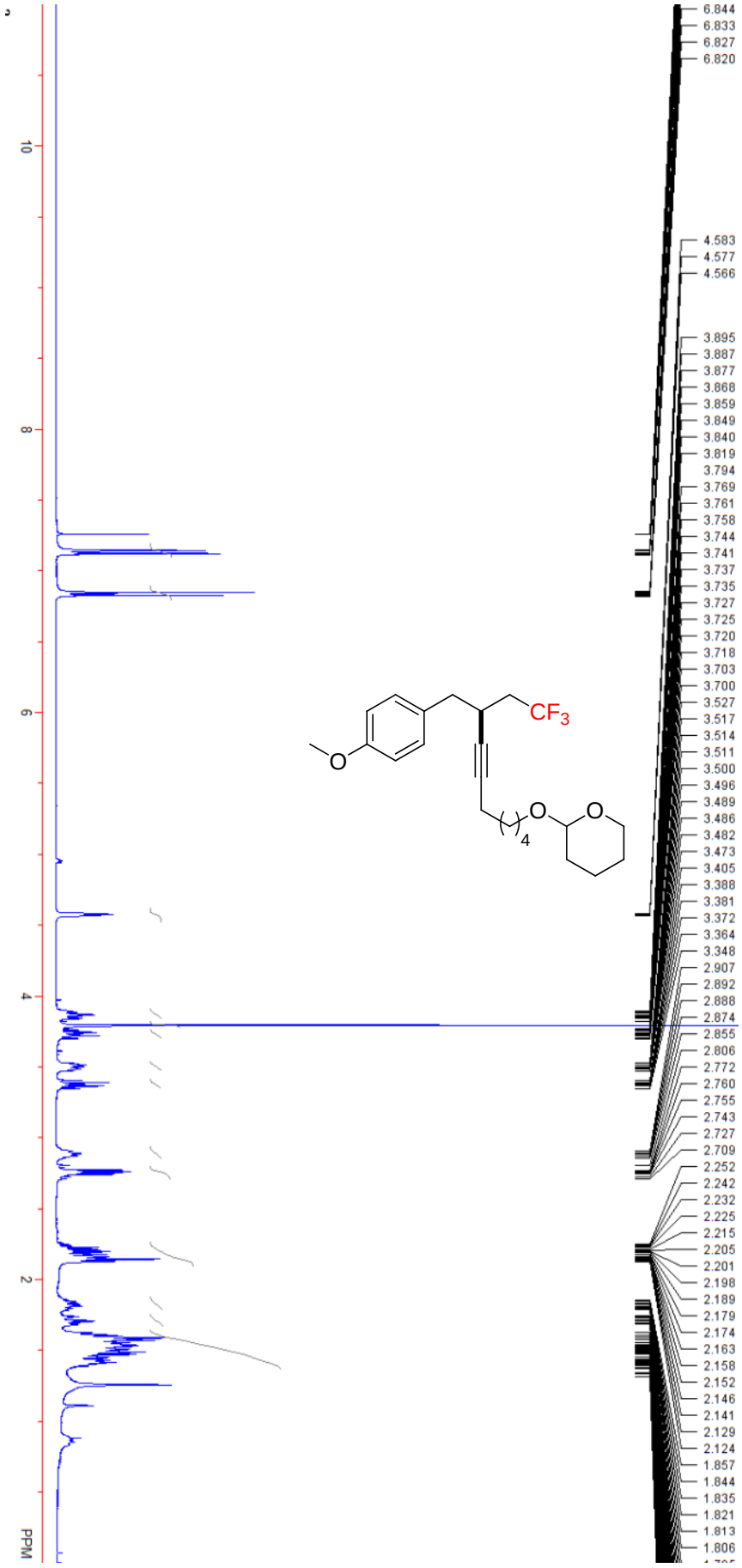
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3.511
3.500
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2.225
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2.205
2.201
2.198
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2.152
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2.124
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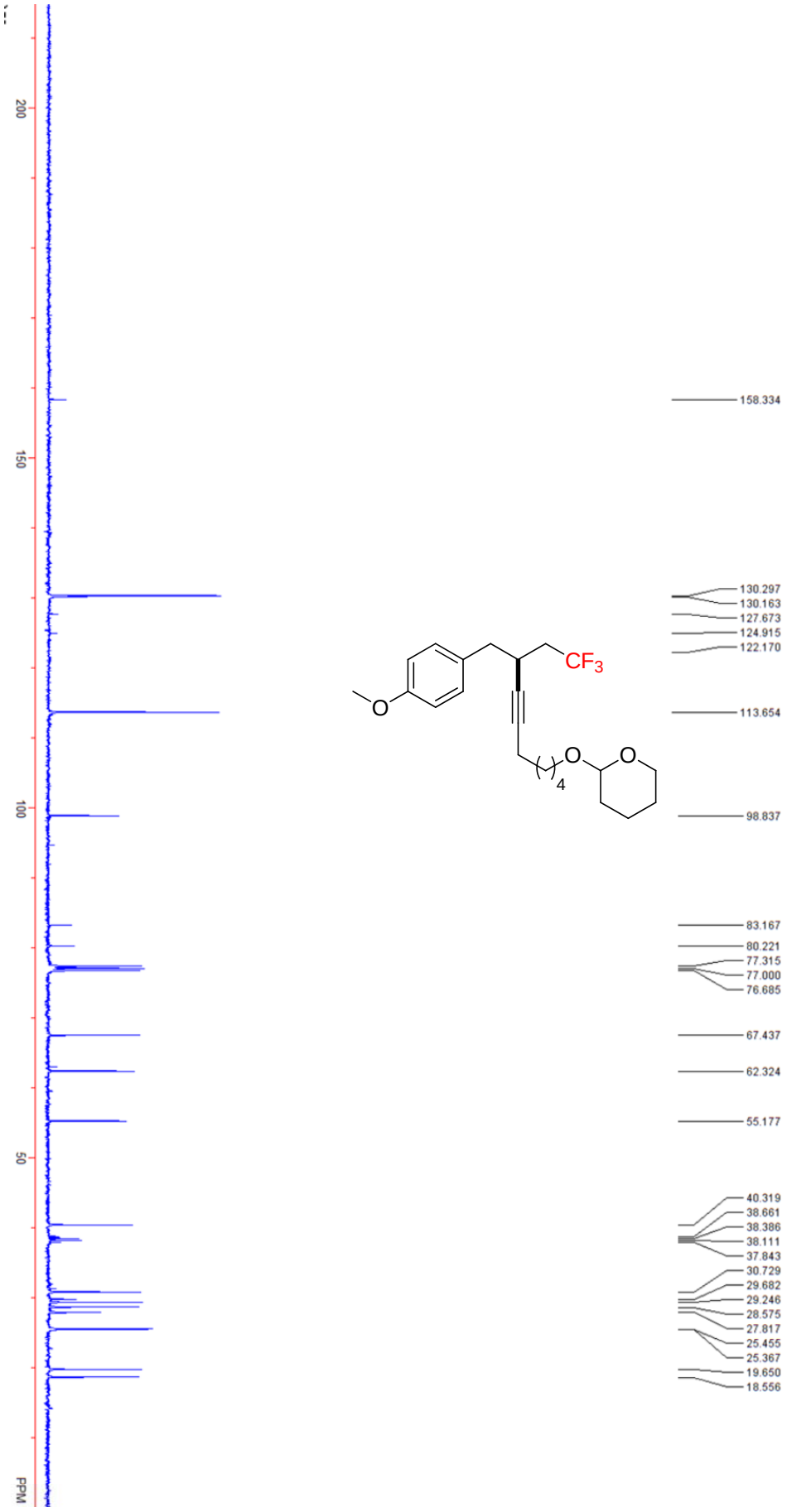
PPM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38.386
38.111
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29.246
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27.817
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PPM
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CF3
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O
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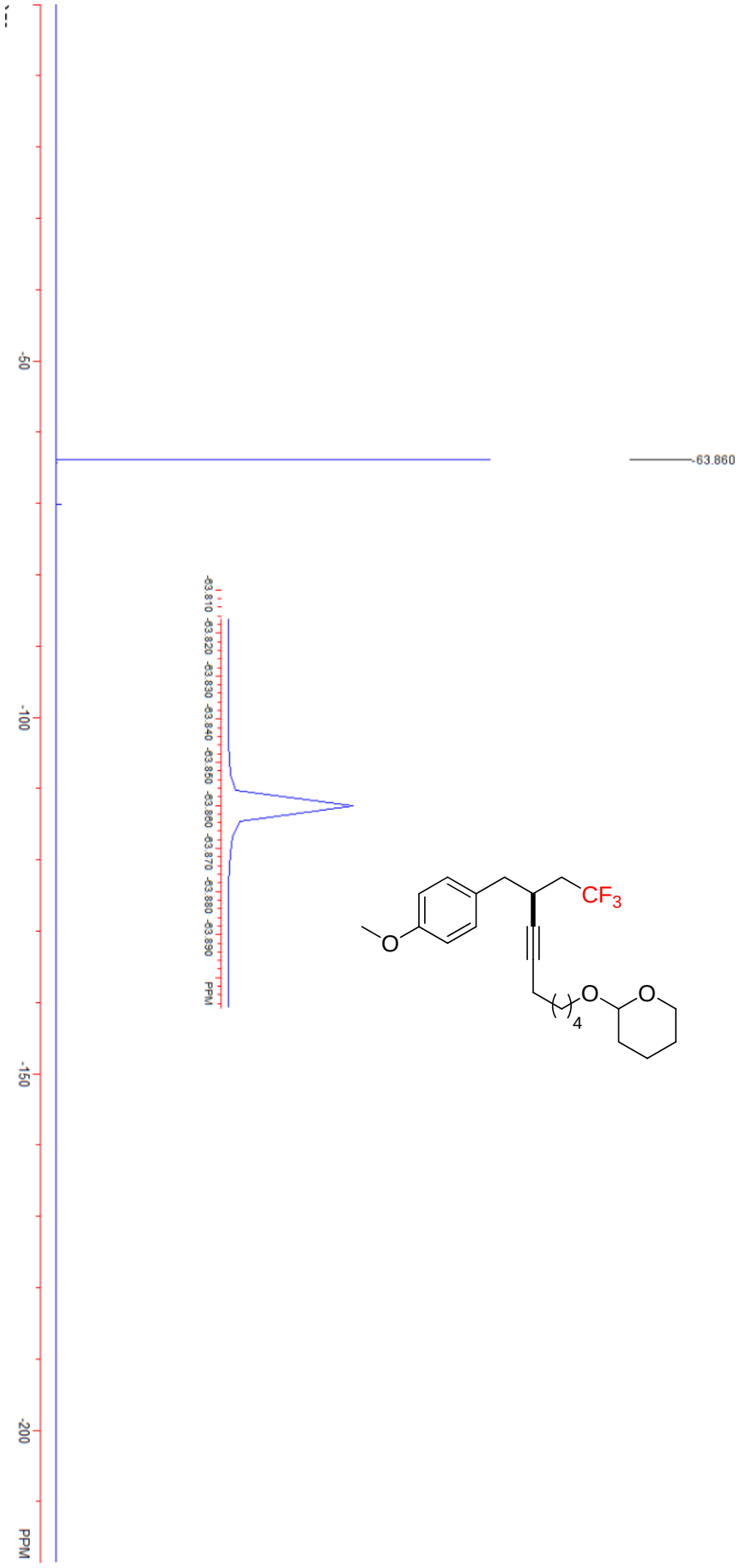
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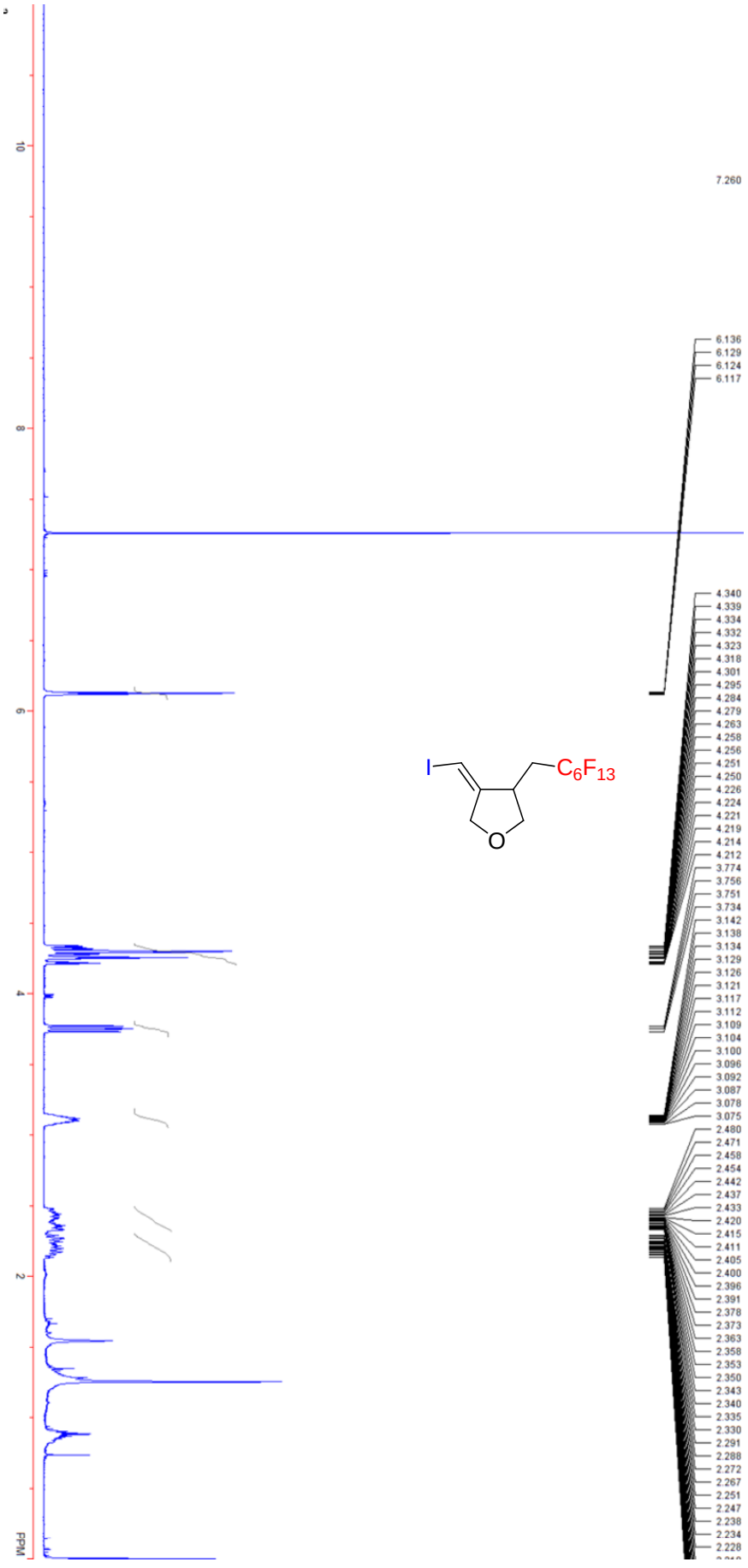
CF3
O
O
O
4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4.295
4.284
4.279
4.263
4.258
4.256
4.251
4.250
4.226
4.224
4.221
4.219
4.214
4.212
3.774
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3.751
3.734
3.142
3.138
3.134
3.129
3.126
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3.117
3.112
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3.104
3.100
3.096
3.092
3.087
3.078
3.075
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2.405
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2.391
2.378
2.373
2.363
2.358
2.353
2.350
2.343
2.340
2.335
2.330
2.291
2.288
2.272
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2.238
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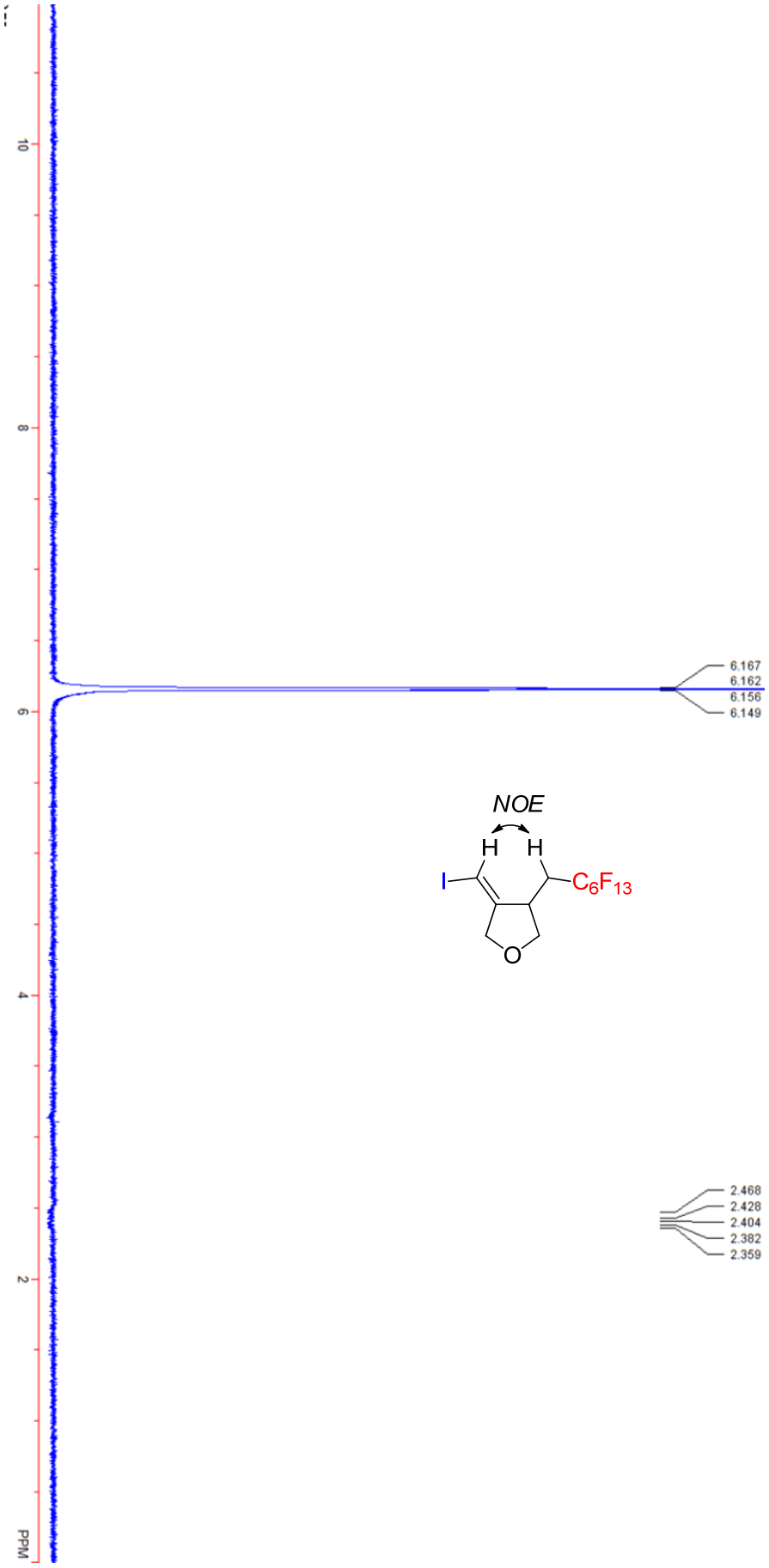
8
6
4
2
PPM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6
4
2
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2.359
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H
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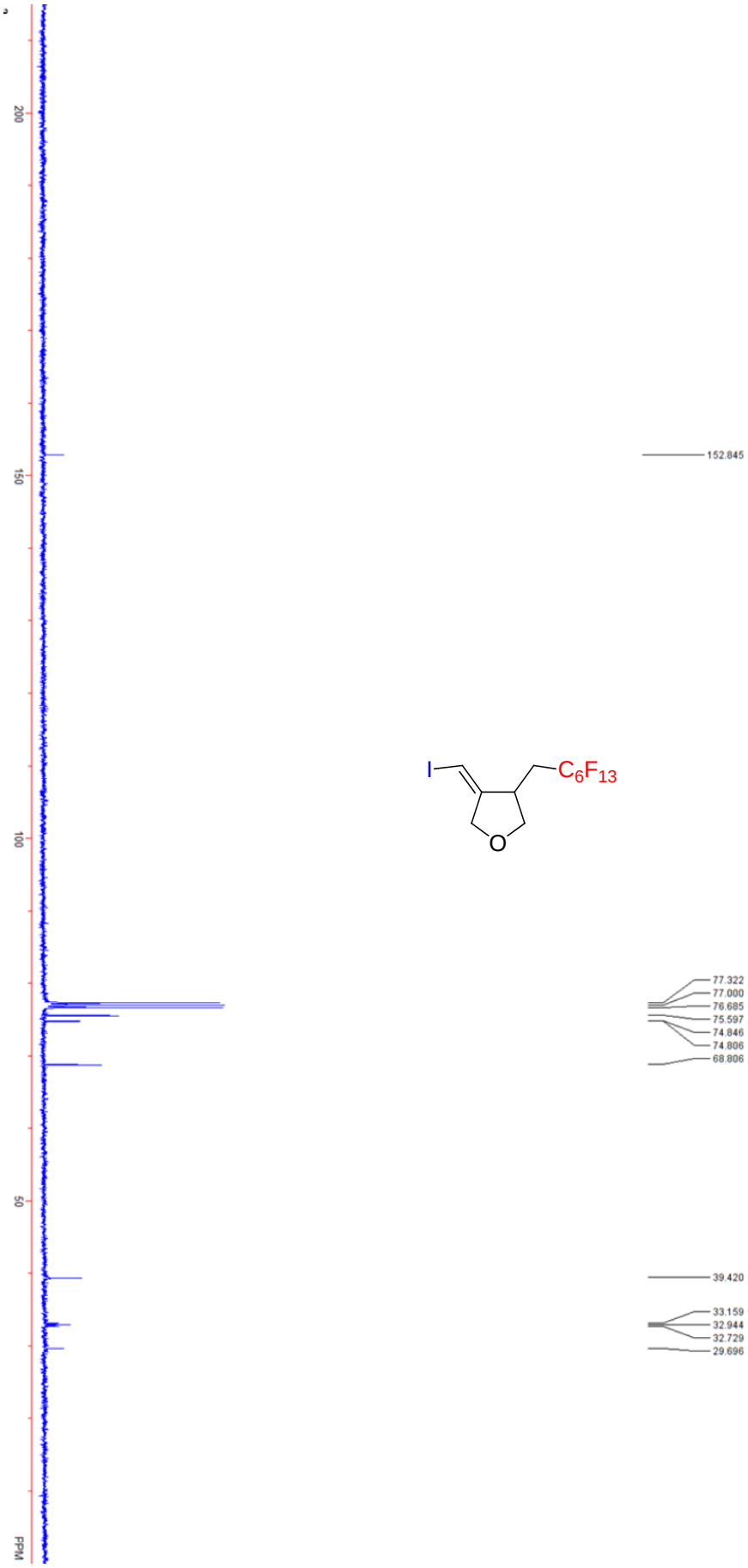
I
C6F13
O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100
50
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32.944
32.729
29.696
I
C6F13
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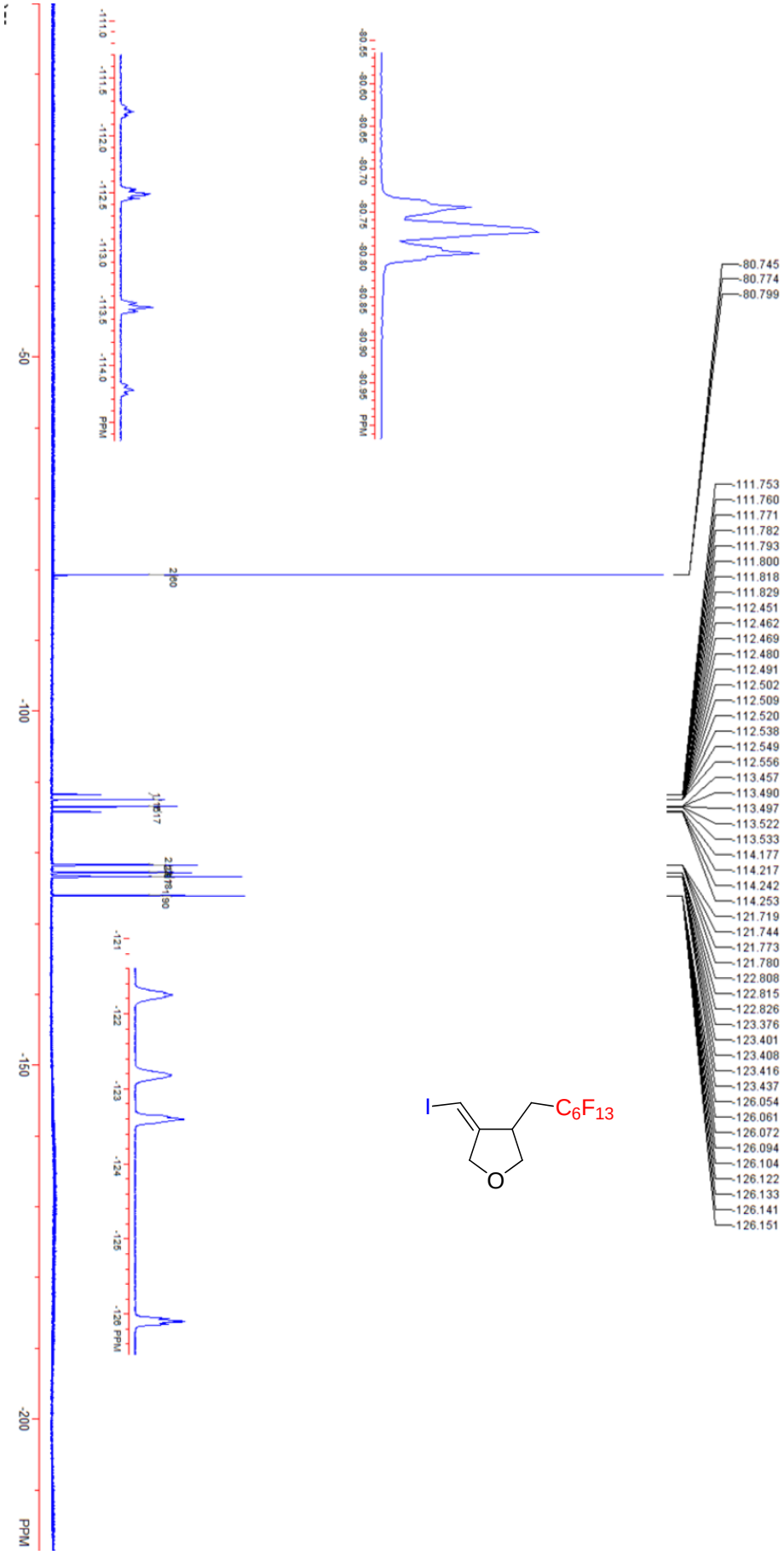
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-200
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-114.0
PPM
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-80.60
-80.65
-80.70
-80.75
-80.80
-80.85
-80.90
-80.95
PPM
200
-121
-122
-123
-124
-125
-126 PPM
80.745
80.774
80.799
111.753
111.760
111.771
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111.800
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111.829
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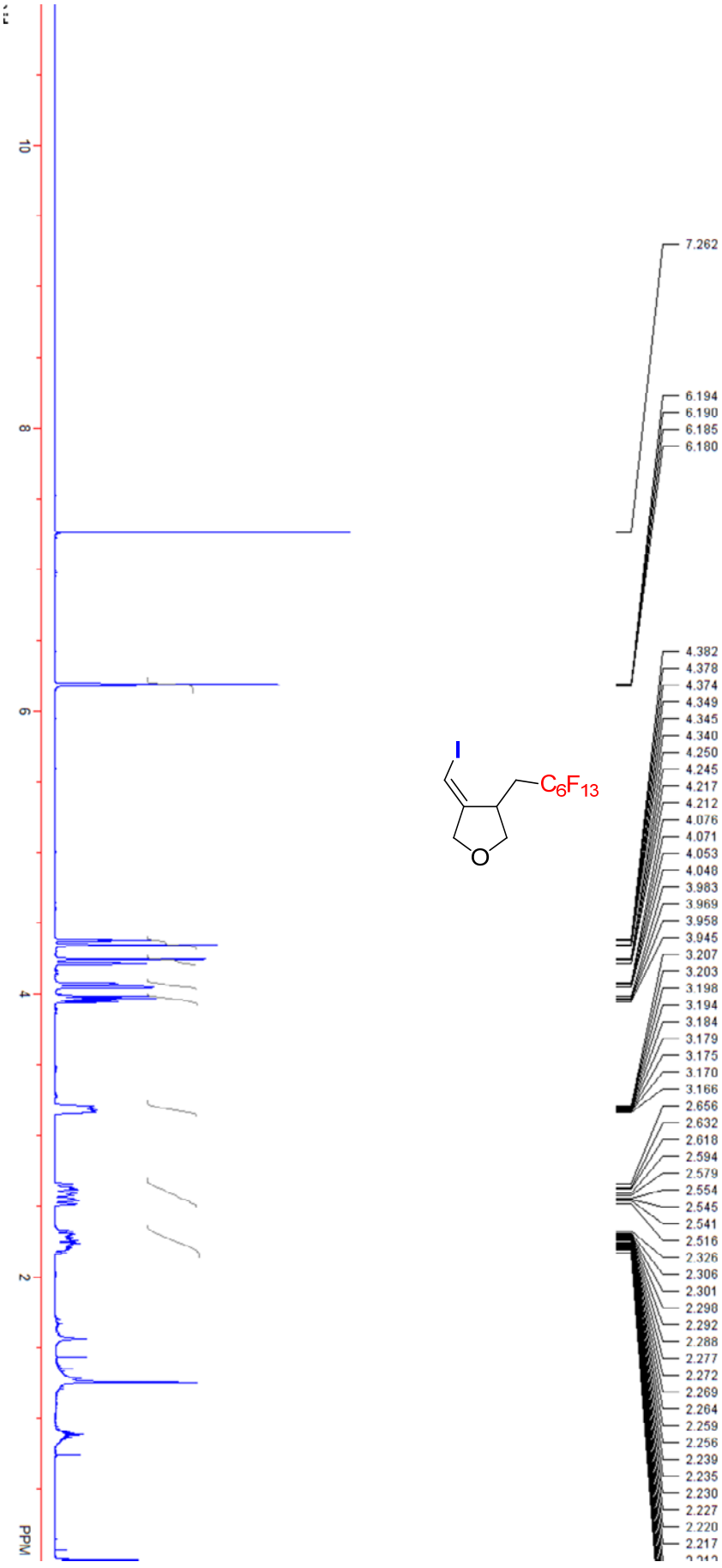
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6
4
2
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6.190
6.185
6.180
4.382
4.378
4.374
4.349
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4.340
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4.245
4.217
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4.071
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3.170
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2.220
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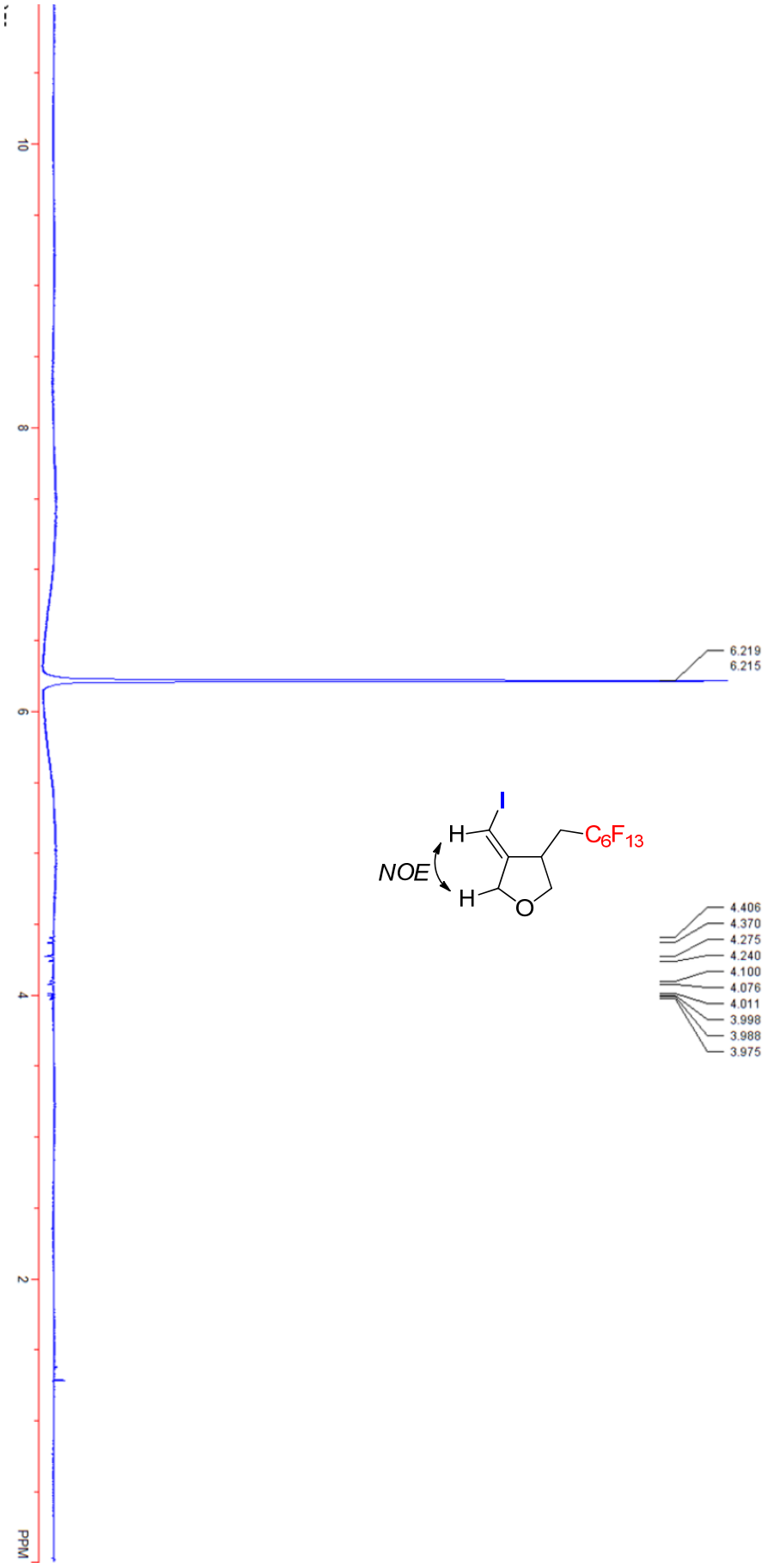
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8
6
4
2
PPM
6.219
6.215
I
H
C_6F_{13}
NOE
H
O
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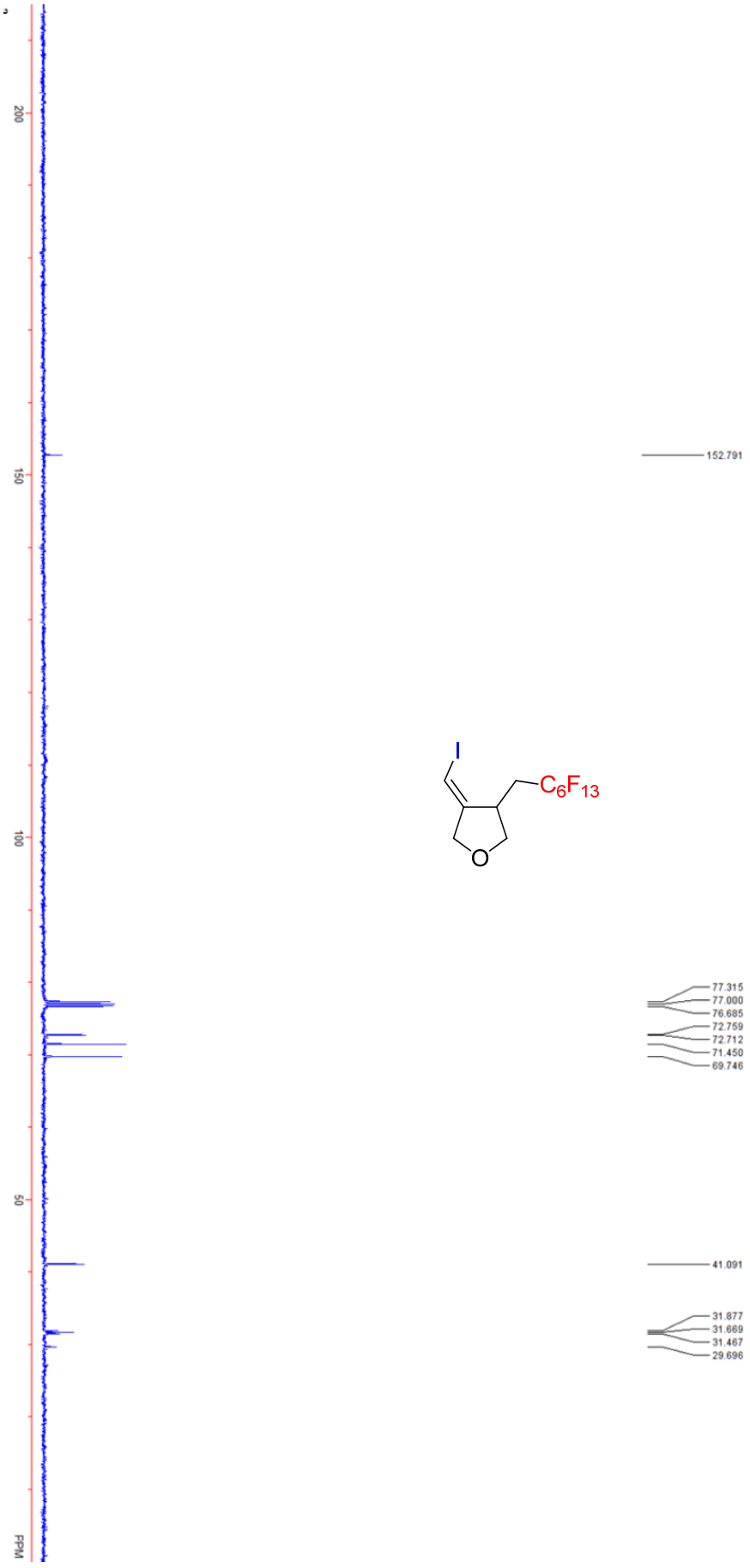
4.370
4.275
4.240
4.100
4.076
4.011
3.998
3.988
3.975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100
50
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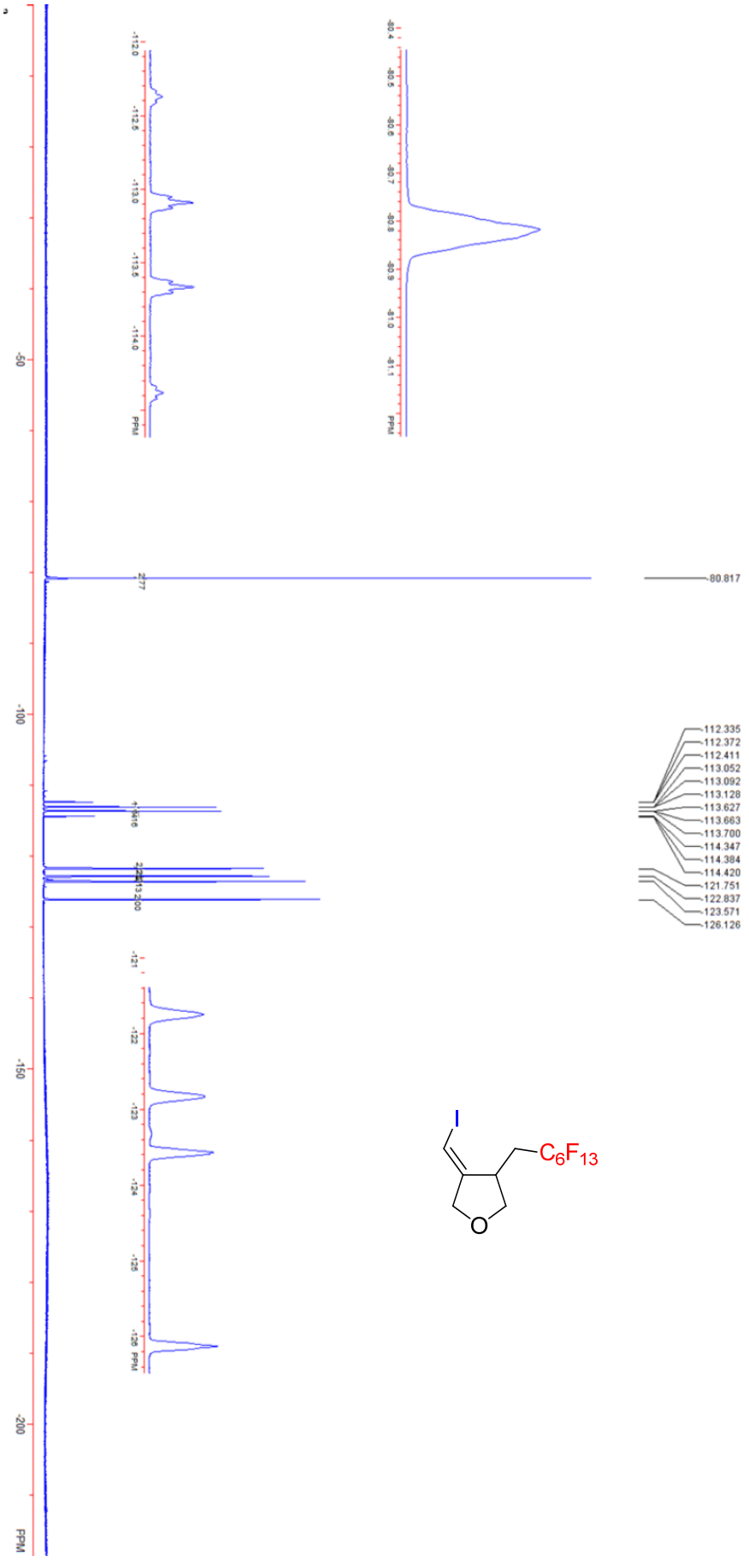
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123.571
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C6F13
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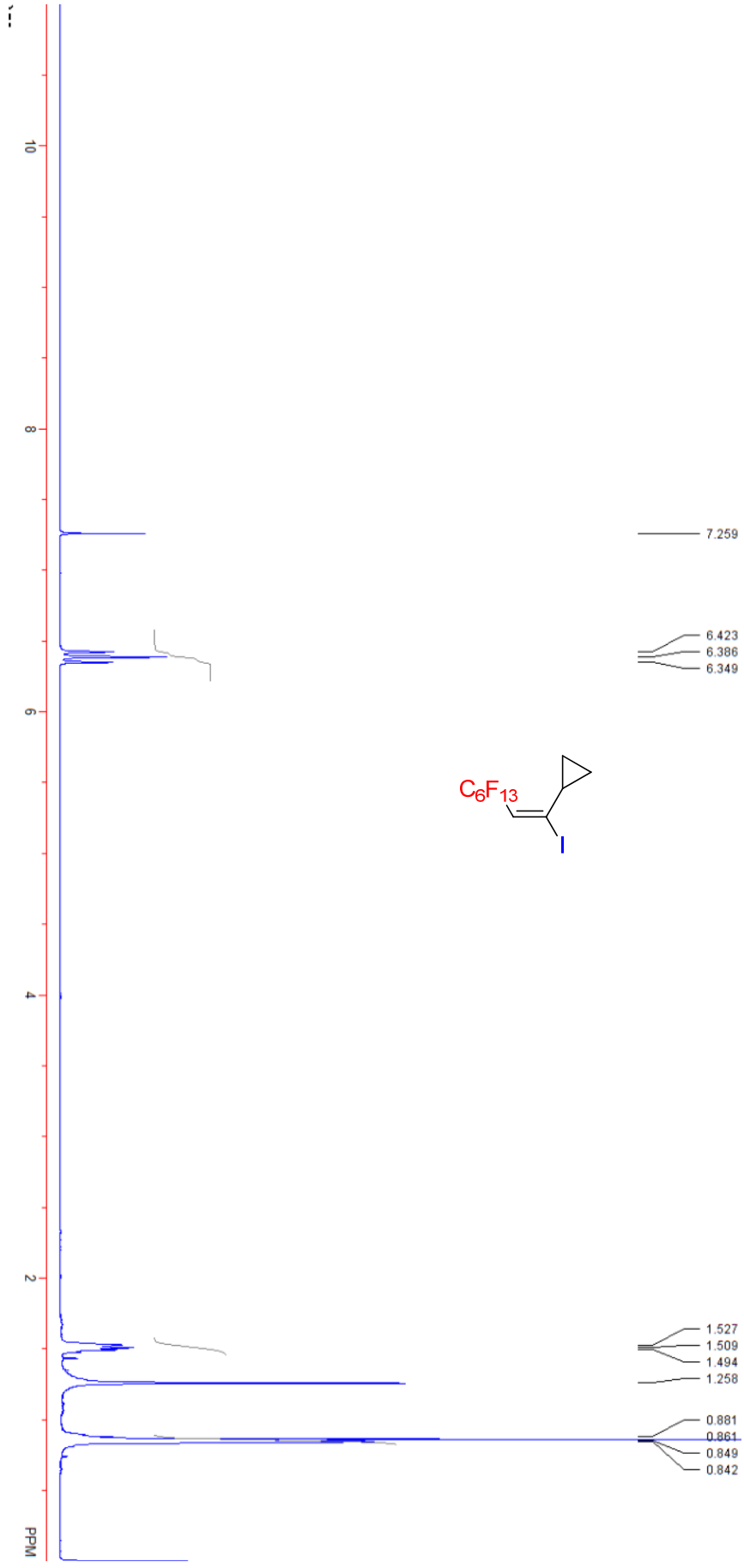
PPM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4
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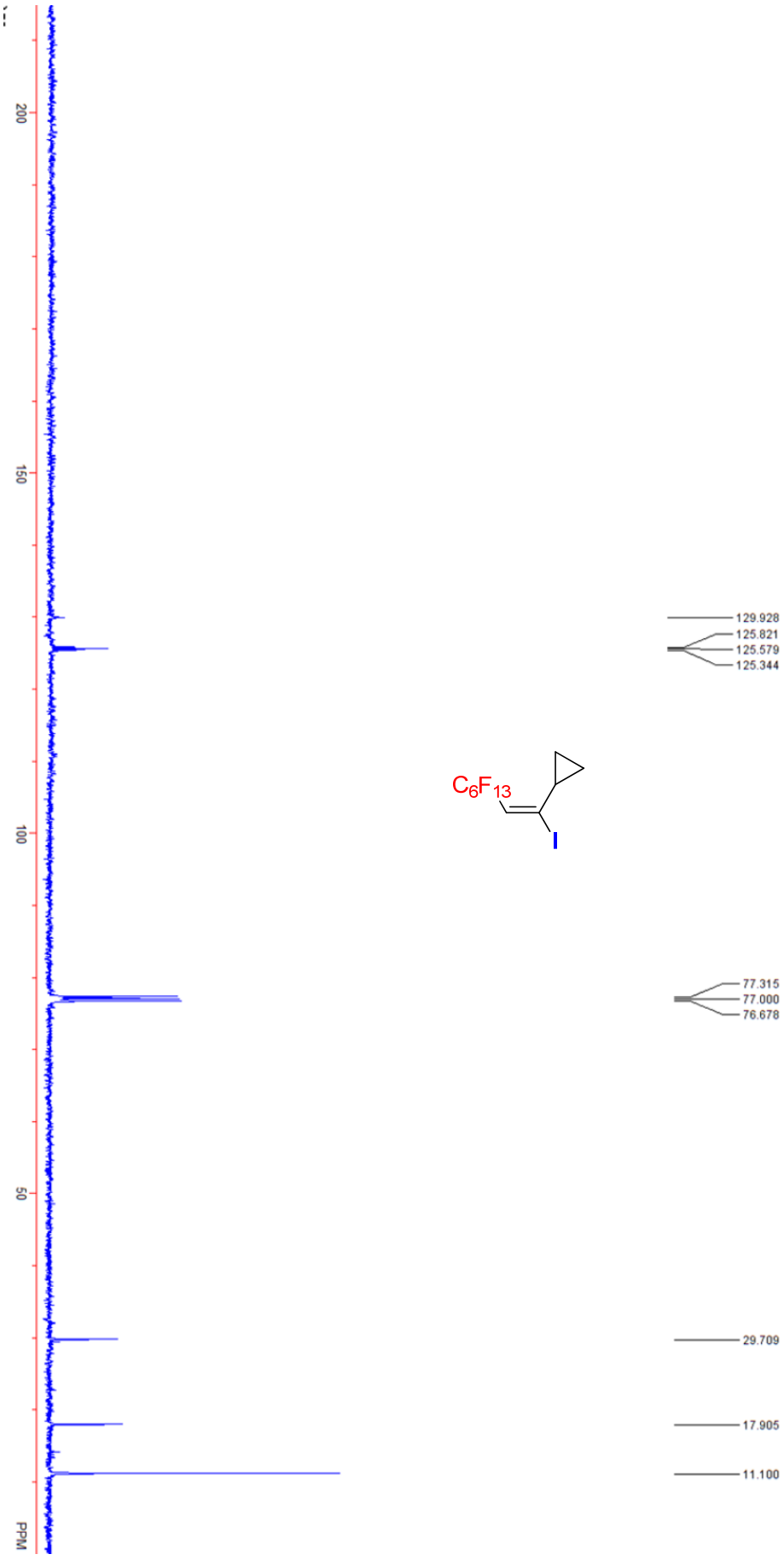
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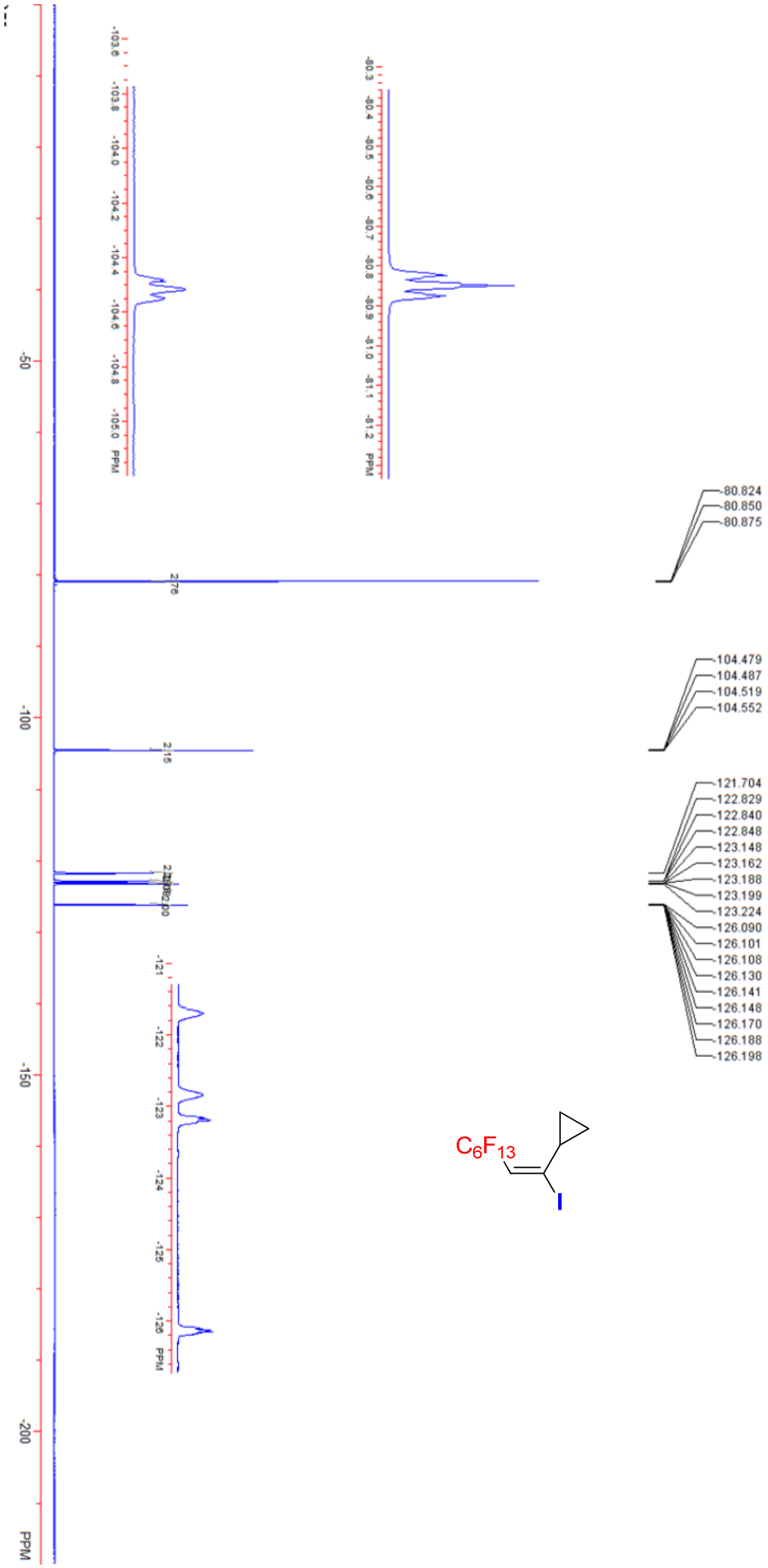
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-80.5
-80.6
-80.7
-80.8
-80.9
-81.0
-81.1
-81.2
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2.15
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-125
-126
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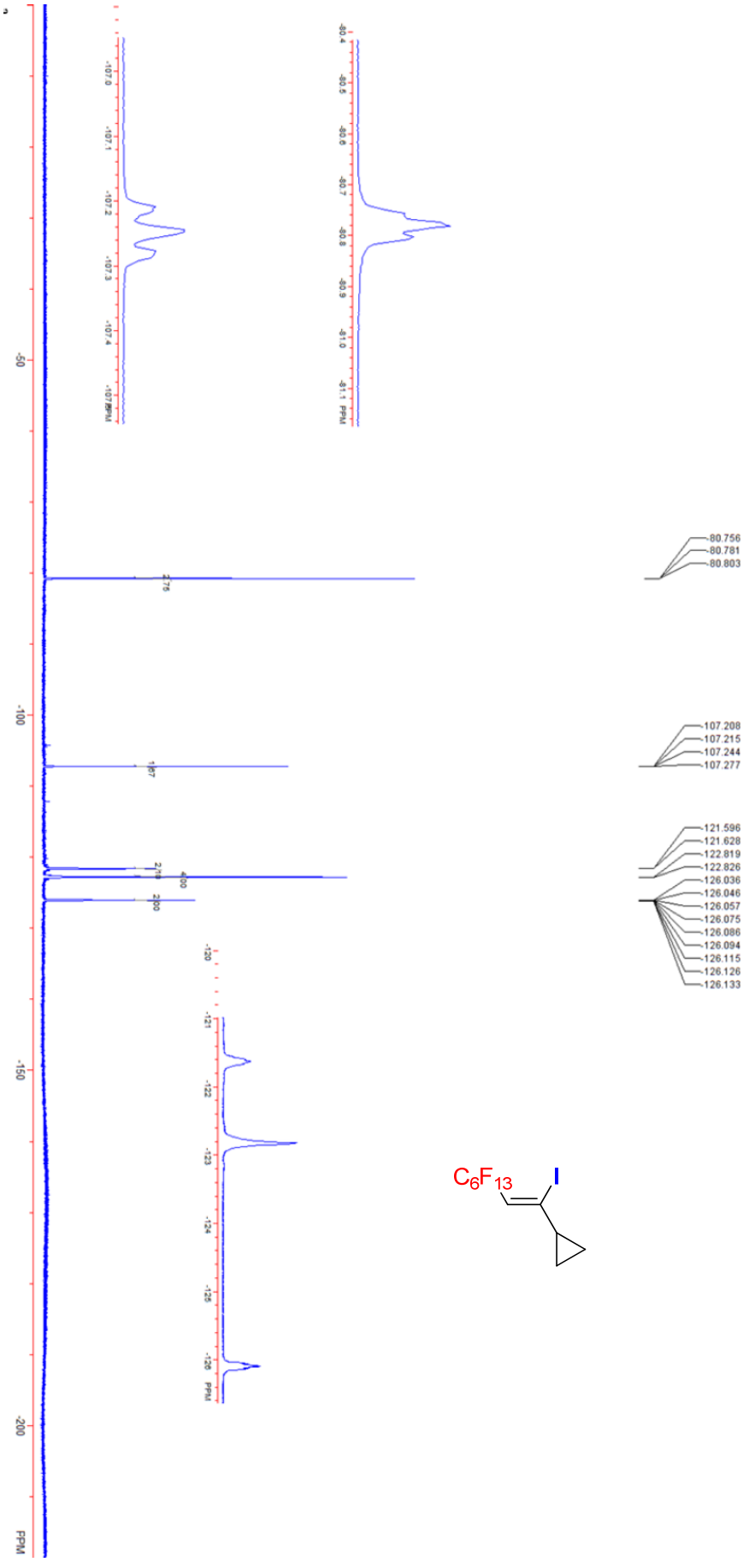
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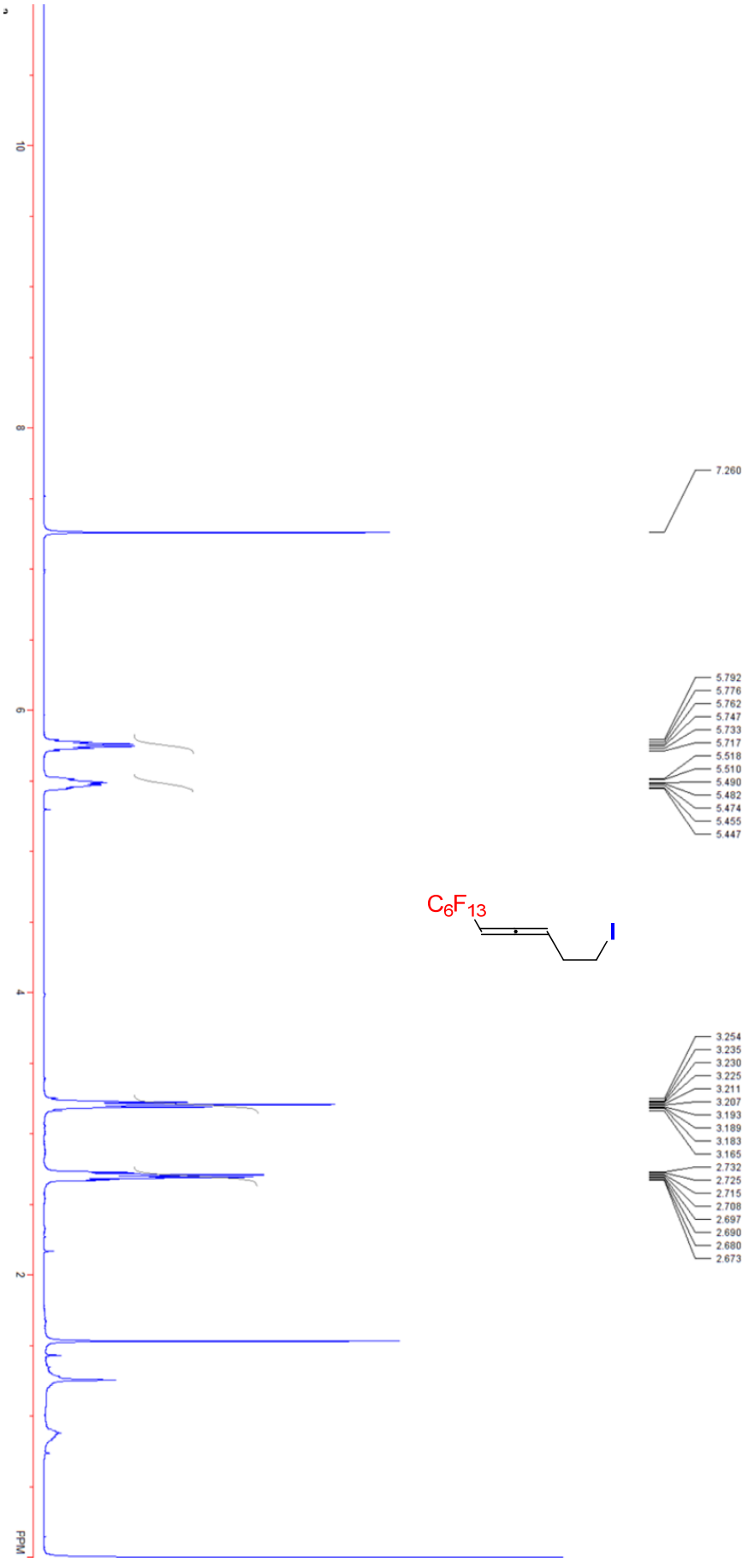
PPM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C6F13
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3.235
3.230
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3.211
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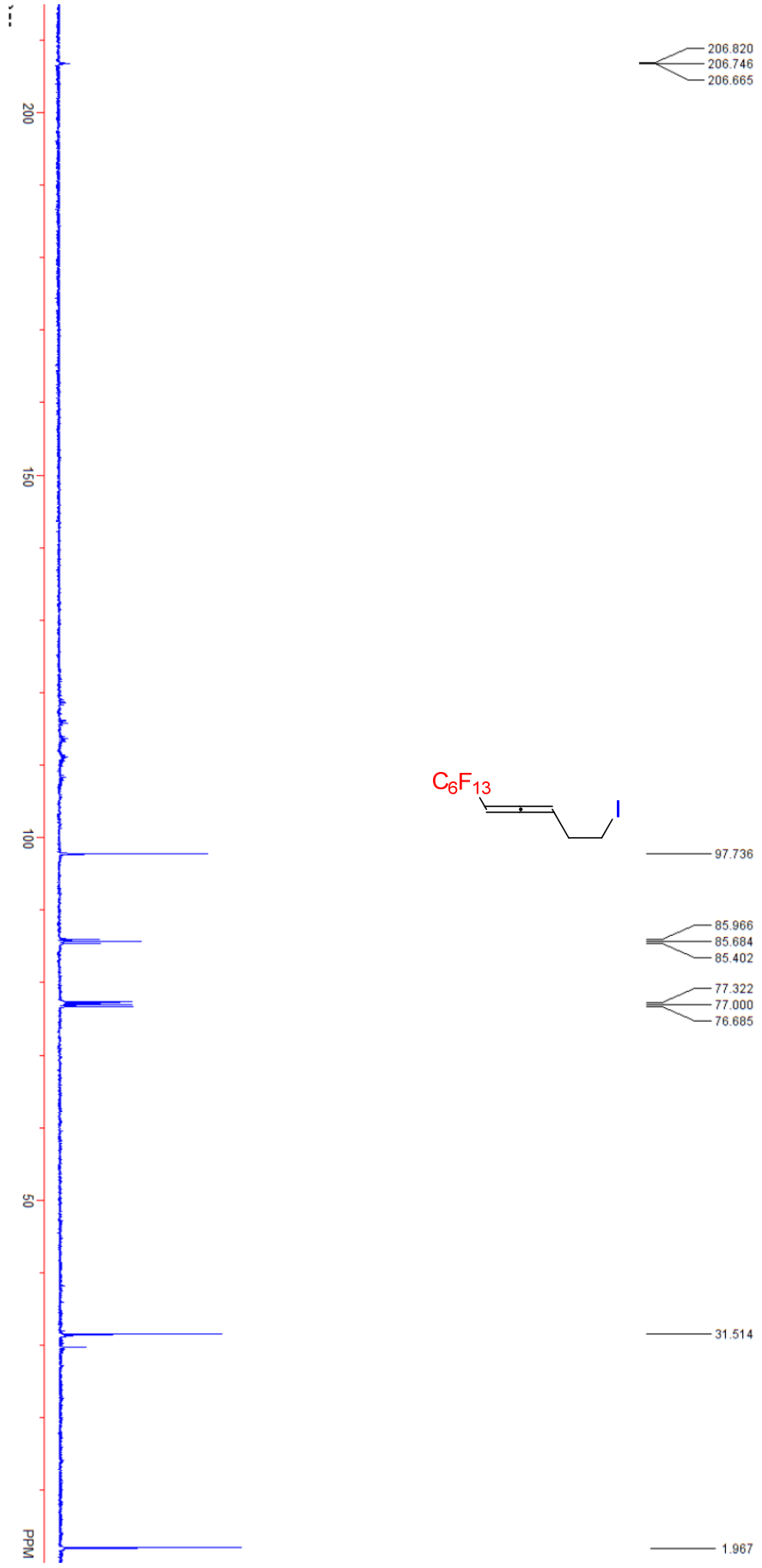
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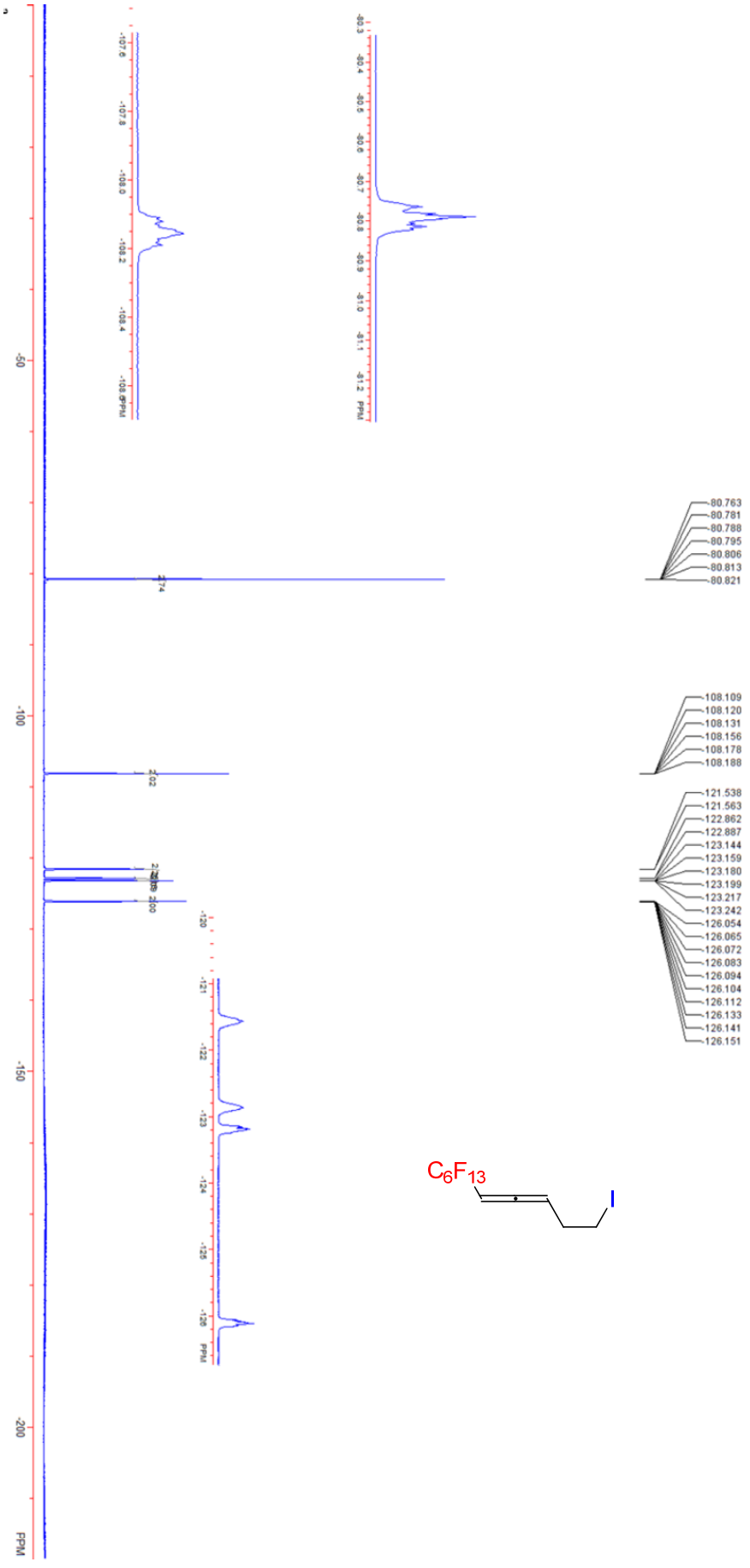
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-126.151
C6F13
I